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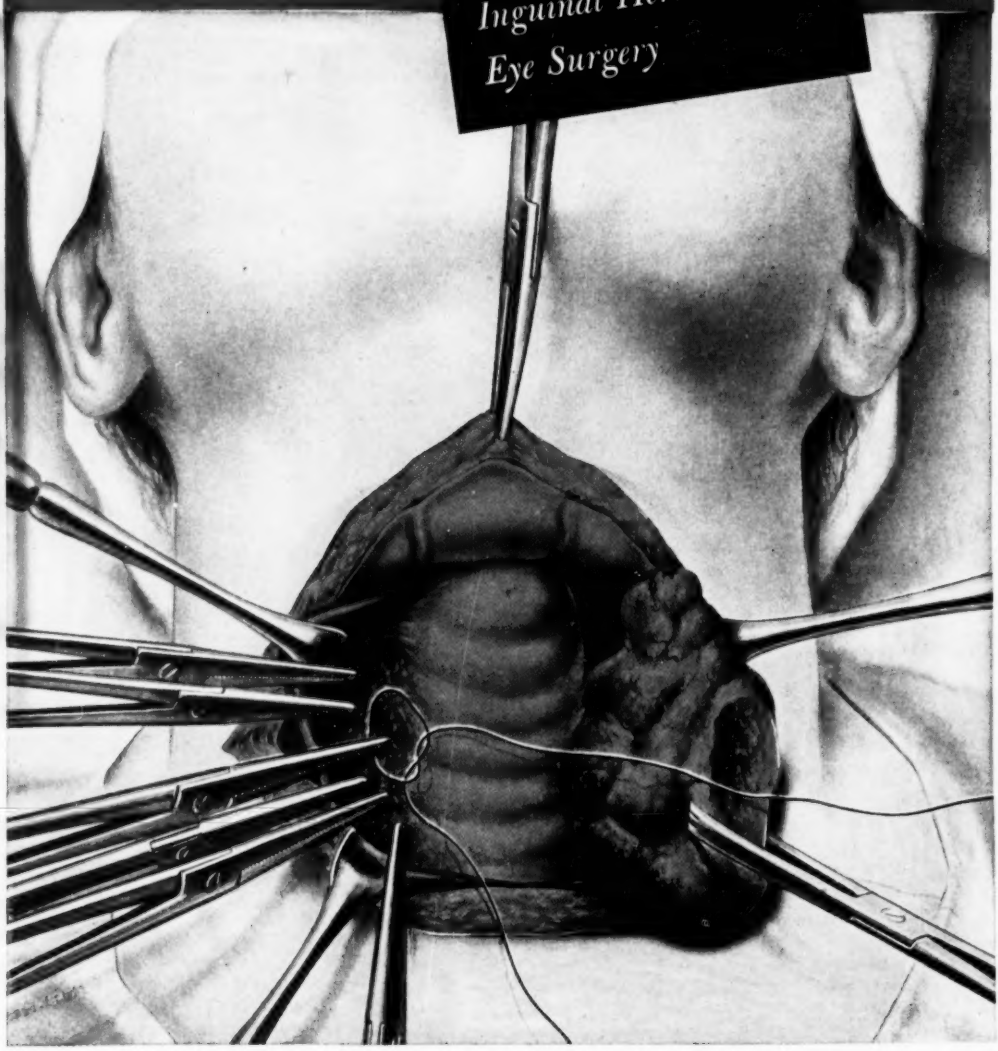

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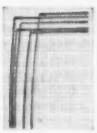

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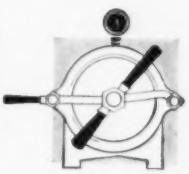

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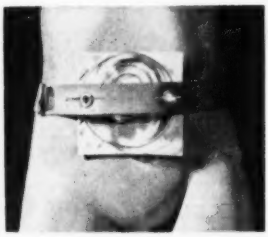

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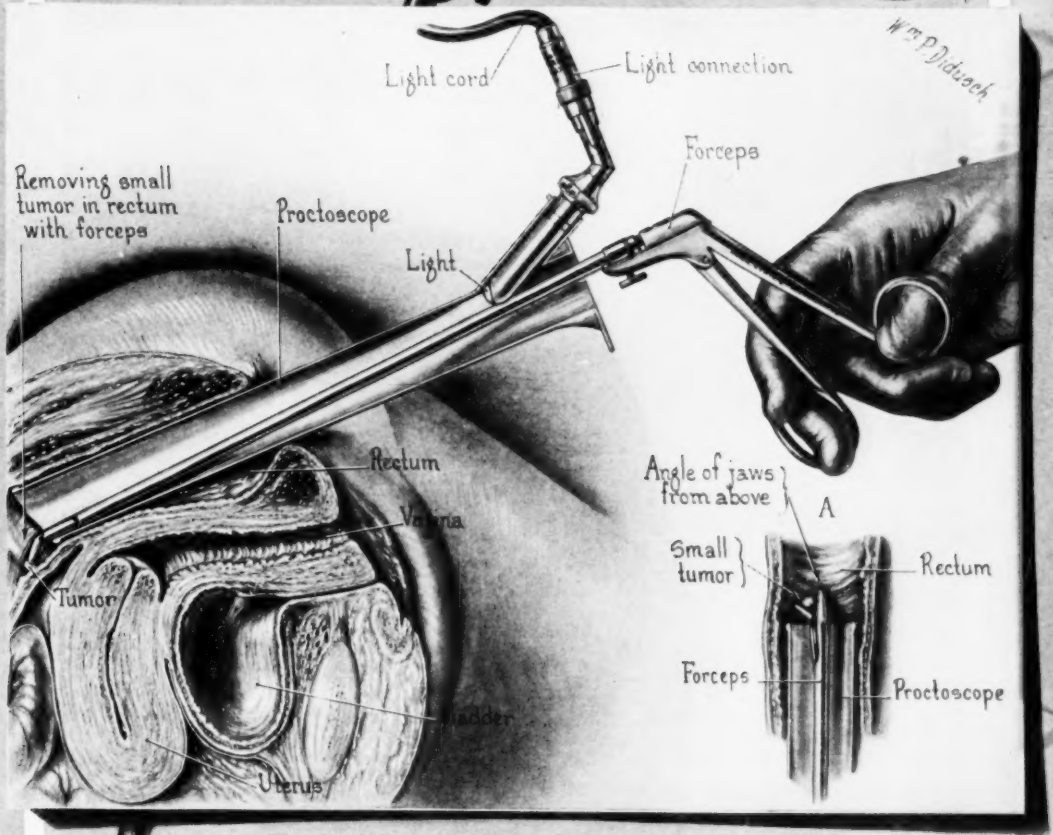

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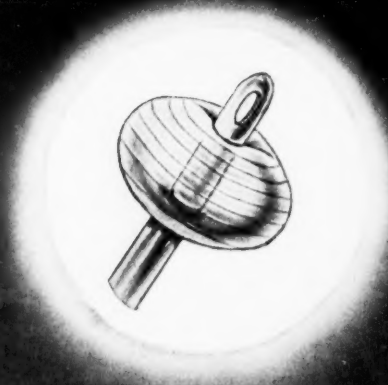

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VOLUME 64 MARCH 1952 NUMBER 3

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THE ELDERLY SURGICAL PATIENT

An Analysis of Five Hundred Consecutive Cases of Patients Sixty Years of Age or Older

DONALD T. BOSCH, M.D.

ABDOL ISLAMI, M.D.

CHARLOTTE T. C. TAN, M.D.

AND

C. ABBOTT BELING, M.D., Med.Sc.D.

NEWARK, N. J.

ELDERLY persons comprise an increasingly larger portion of our population. Groom[1] has shown that whereas the entire population of the United States increased only 7% between 1930 and 1940, the number of people from 65 to 74 years of age increased 35%, and the number over 75 years of age increased 38%. On the basis of this trend, it has been estimated that by 1980 20% of our population will be 60 years of age or older. The Metropolitan Life Insurance Company[2] has reported a progressive average lengthening of life of its industrial policyholders from 55.8 years in 1929 to 62.5 years in 1939 and 67.8 years in 1949. The importance of surgery on elderly persons is, therefore, readily apparent.

This study is a review of 500 consecutive patients 60 years of age or older who were subjected to major surgical operations at the Hospital of Saint Barnabas between May 1, 1947, and Dec. 11, 1949. Preoperative blood volume had been determined in 65 of the patients, with correction of deficits. It is our purpose to analyze the surgical tolerance of the elderly patient and to determine what improvements may be made in management.

The number and types of operations are listed in Table 1. No case was utilized twice. When the same patient had undergone more than one major operation during the period of this study, the procedure of the greatest magnitude was selected. Forty-four per cent of the patients previously had undergone one or more surgical operations. This would roughly indicate that in American metropolitan areas nearly half of the population will have been subjected to some form of major surgery by the time 60 years of age is reached.

MORTALITY FACTORS

Our hospital mortality rate for all major surgical procedures during the period covered was 3.01%. We defined a surgical death as one which followed surgery regardless of cause or of time between operation and death provided the patient was

From the Department of Surgery, Hospital of Saint Barnabas.

1. Groom, W. S.: Mortality and Life Expectancy in the United States Since 1900, Geriatrics **1**:384-390 (Sept.-Oct.) 1946.

2. Health and Longevity at the Mid-Century, Statist. Bull. Metrop. Life Insur. Co. **31**:1-7 (Jan.) 1950.

still in the hospital. If palliative and purely exploratory operations were to be excluded, the mortality rate would drop to 2.3%.

The present series of patients over 59 years of age carries a hospital mortality rate of 9.6%, about three times the rate for all major surgical cases. The numerous

TABLE 1.—*Types of Operations in 500 Cases*

Radical maxillofacial surgery for cancer	9
Radical neck dissection for cancer	5
Laryngectomy	2
Radical mastoidectomy	2
Thyroidectomy	7
Radical mastectomy	23
Subtotal gastric resection	19
Repair of perforated duodenal ulcer	4
Palliative internal drainage—carcinoma of pancreas	7
Pancreatoduodenectomy for carcinoma of pancreas	2
Cholecystectomy	45
Choledochotomy with or without cholecystectomy	11
Cholecystostomy	4
Appendectomy	16
Lysis of adhesions	7
Laparotomy without further surgery	23
Splenectomy	2
Ileotransverse colostomy for ileitis	2
Resection of colon, partial	22
Abdominoperineal resection	8
Colostomy	22
Total abdominal hysterectomy	8
Vaginal hysterectomy	28
Oophorectomy	6
Inguinal herniorrhaphy	40
Femoral herniorrhaphy	3
Anterior and posterior colporrhaphy	18
Nephrectomy	4
Orchidectomy	3
Excision of hydrocele	7
Cystotomy	8
Suprapubic prostatectomy	46
Transurethral prostatectomy	15
Cystectomy for carcinoma of bladder	8
Amputation of leg	15
Arthrotomy	2
Open reduction of fractures (excluding hips)	4
Hip pinning	22
Subtrochanteric osteotomy	2
Vagotomy, total gastrectomy, ligation of vena cava, umbilical herniorrhaphy, ureterolithotomy, gastrostomy, lumbar sympathectomy, resection of esophageal diverticulum, cervical chordotomy, repair of vesicovaginal fistula, excision of thyroglossal sinus, craniotomy, mediastinotomy, resection of small bowel, extensive skin grafting, resection of esophagus, thoracic exploration, Watkins interposition operation, removal of gall stone causing obstruction, 1 each	19
	500

TABLE 2.—*Mortality According to Age Groups*

Age	Cases	Deaths	Percentage
60-64	195	12	6.15
65-69	146	8	5.41
70-79	118	19	16.10
80-89	37	8	21.70
90 and over	4	1	25.00

factors which contribute to this higher rate, such as the increased incidence of malignant disease in older persons and the greater number of arteriosclerotic cardiovascular disorders, will be discussed.

Influence of Age.—The mortality according to age grouping is shown in Table 2. As might have been expected, there is a rise in the death rate with increasing age. There is, however, a sharp increase (5.41% to 16.1%) once 70 years have elapsed. This increase is consistent with the thoughts of the Psalmist who wrote some three thousand years ago.

> The days of our years are threescore years and ten; and if by reason of strength they be fourscore years, yet is their strength labour and sorrow; for it is soon cut off, and we fly away. Psalm 90:10.

We were impressed with the remarkable manner in which very old patients withstood surgery. Three of the four patients over 90 years of age made excellent postoperative recoveries, as did 29 of the 37 over 80 years of age. Age alone usually should not contraindicate surgery. One philosophical approach to these very old patients is that persons possessing the intrinsic good health to live to be 80 also frequently possess the necessary reserve to withstand major surgery. Another factor is that years alone do not necessarily determine a man's mental and physiological age, since many very old persons are actually much younger than their chronological juniors.

TABLE 3.—Mortality Based on Anesthetic Agent

Agent	Cases	Mortality, %
Cyclopropane	160	9.3
Nitrous oxide, oxygen and ether	124	8.8
Thiopental (pentothal®) sodium	122	8.0
Spinal and thiopental (pentothal®) sodium	62	12.9
Local, procaine	19	21.0
Tribromoethanol (avertin) and nitrous oxide, oxygen, and ether	8	0.0
Cyclopropane and thiopental (pentothal®) sodium	5	0.0

Effect of Anesthesia.—The mortality based on the anesthetic agents employed is shown in Table 3. The majority of patients received cyclopropane, combined nitrous oxide-oxygen-ether, thiopental (pentothal®) sodium or an intrathecal agent plus thiopental sodium. The mortality was essentially the same regardless of the agent used. The relatively higher death rate with local anesthesia probably is due to the fact that procaine was used in several patients who were considered too critical for any other anesthetic. We agree with Parsons and Purks[3] that a skilled anesthetist is much more important than the special anesthetic agent employed.

Influence of Other Diseases.—Two hundred forty patients were free from disease other than that for which they underwent surgery. There were 16 deaths in this group, as compared with 32 deaths in the remaining 260 with concurrent disease. The difference between the percentages is 5.7, and the standard error of the difference is 2.59. The distribution of concurrent disease is shown in Table 4. Hypertension was considered present when the systolic blood pressure exceeded 150 mm. of mercury and the diastolic pressure 96 mm. of mercury. We chose this criterion because 149 systolic and 95 diastolic or less is commonly con-

3. Parsons, W. H., and Purks, W. K.: The Elderly Patient as a Surgical Risk, Arch. Surg. **58**:888-906 (June) 1949.

sidered "normal" blood pressure. Russek and Zohman [4] have shown that the systolic blood pressure increases significantly with age whereas the diastolic pressure varies little after the sixth decade. Hypertension was the most frequent concurrent disease, occurring in 180 patients of the total 260 and carrying a mortality rate of 9.44% (17 deaths). The remaining 15 deaths all occurred in the arteriosclerotic group of 44 patients, giving the high death rate of 34.1%. In the latter group were the patients with generalized arteriosclerosis with severe damage to the myocardium, the coronary vessels, or the kidneys. Diabetes mellitus occurred in 22 cases and was a contributory cause of death in 3 cases. Five patients had

TABLE 4.—*Concurrent Disease*

Arteriosclerosis (including kidneys, myocardium, and coronary arteries)	44
Hypertension	180
Diabetes mellitus	22
Arthritis	5
Rheumatic heart disease	2
Heart block	1
Prostatic hypertrophy (severe)	1
Diverticulitis of colon	1
Tuberculosis (pulmonary)	1
Hemiplegia	1
Bronchial asthma	1
Malaria	1
Total	260

TABLE 5.—*Causes of Death*

Cardiac failure	10
Peritonitis	8
Renal failure	7
Pneumonia	5
Pulmonary embolism	5
Carcinomatosis	5
Cerebral hemorrhage	2
Postoperative shock	3
Septicemia	1
Hemorrhage	1
Metastatic carcinoma in brain	1
Total deaths	48

arthritis, and one of them died. None of the other concurrent diseases influenced the outcome fatally. The fact that twice as many patients with concurrent diseases succumb to surgery as those who are free of such diseases emphasizes the importance of close cooperation between the surgeon and the internist in the preoperative and postoperative management of elderly persons.

ANALYSIS OF DEATHS

There were 48 deaths in the 500 cases. The causes of death based on clinical and autopsy findings appear in Table 5. Ten deaths were due to cardiac failure

4. Russek, H. I., and Zohman, B. L.: Normal Blood Pressure in Senescence: A Study of 3,691 White Male Subjects Between the Ages of 50 and 95 years, Geriatrics **1**:113-120 (March-April) 1946.

in patients with a preoperative diagnosis of cardiac disease. More deaths from cardiac failure might have been expected, because 226 patients were classified preoperatively as having hypertension or cardiac disease. We agree with Morrison [5] that arteriosclerotic hearts which do well under every-day work may fail under the stress of surgery. These cardiovascular disorders, however, need not impose undue surgical risk if properly handled.

The role of infection must be emphasized. Eight patients died of peritonitis, 6 from pneumonia, and 1 from septicemia, making a total of 15. Although the mortality from infection would probably have been higher if not for the use of antibiotics, let us remember that they are not substitutes for basic surgical principles.

The seven deaths from kidney failure with uremia stress the need for evaluation of kidney function in elderly patients One death was due to hemorrhage from ruptured esophageal varix. Five deaths from pulmonary embolism included three in patients with cancer, which is in line with the predisposition to embolism in malignant disease. All five received anticoagulant therapy.

Three deaths from postoperative shock are regrettable. All patients were inadequately prepared for operation and exemplify the unnecessary risk of major surgery in the presence of blood volume deficits. From the standpoint of operating technic the cases were properly handled, but insufficient attention was given to physiological management.

There were 28 deaths from malignant disease, comprising 58% of the total. On this basis, more than half of all deaths in patients over 60 years of age may be caused by cancer or its complications. Malignant disease must be suspected in every elderly patient.

Emergency Versus Elective Surgery.—The 46 emergency operations resulted in eight deaths, giving a mortality of 17.4%. The 454 elective procedures resulted in 40 deaths, with a mortality of 8.8%. The problem of rapid preoperative preparation is evidenced by the comparatively high mortality from emergency surgery. Three of the eight deaths were due to cancer, two to intestinal obstruction from adhesions and a gall stone, respectively, one to perforated duodenal ulcer with peritonitis, one to massive upper gastrointestinal hemorrhage, and one to diverticulitis with perforation and peritonitis.

The high mortality associated with emergency surgery is an indication that these patients should be put into optimum condition as rapidly as possible. In our experience, this may be accomplished best by adequate blood volume studies followed by quantitative replacement and attention to electrolyte balance. We have been impressed with the excellent manner in which cardiac patients respond to blood-volume replacement. With ordinary care, overloading does not occur and the patients show progressive improvement as blood volume is brought to normal. The theoretical danger of overloading is of little importance compared with the certain danger of emergency surgery in the face of deficient blood volume with its accompanying hemoglobin shortage and inevitable hypoxia. Most of these patients

5. Morrison, D. R.: The Risk of Surgery in Heart Disease, Surgery **23**:561-570 (March) 1948.

readily tolerate 1,000 ml. of blood daily, and most of them, being chronically ill, have deficits over 1,000 ml.

MORBIDITY FACTORS

The postoperative morbidity was based on four factors: the duration of hospital stay, the period of complete bed rest, the number of days with an elevation of temperature to 100.5 F. or more, and the postoperative complications. The average period of postoperative hospitalization was 16.4 days. The majority of patients were discharged in less than two weeks, but the average was increased by the few patients who had multiple-stage operations, severe complications, or problems of home care. It should be noted that, although they represent the more difficult cases, the patients in whom blood volume studies were carried out were discharged one day earlier than the average patient.

The average period of bed rest was 3.6 days. The average time during which a temperature of 100.5 F. or over lasted was 3.9 days. By definition, a febrile day was one during which the temperature touched 100.5 F. at any time during the 24-hour period. There was no statistically significant difference between the large group without blood volume studies and the 65 patients in whom such studies were made. Most of the patients made relatively afebrile recoveries from operation, the average being increased by a few cases with severe complications.

POSTOPERATIVE COMPLICATIONS

The incidence of surgical complications is somewhat difficult to define. Certain problems such as embolism and wound infection represent obvious complications. However, many postoperative diseases are partially or entirely masked by the use of antibiotics. Because of this probable source of error, we included as a complication every case in which the temperature reached 100.5 F. during the first six postoperative days. This gives a grand total of 103 patients. Thus slightly more than one-fifth of all five hundred patients had some form of postoperative infection and 71% of all the complications were due to infection. Infection, therefore, constitutes a major danger in elderly surgical patients. The majority of complications in cases in which infection was not involved consisted of renal insufficiency, embolism, cardiac failure, hemorrhage, hiccough, necrosis of skin flaps and evisceration. One patient pulled out her choledochostomy tube on the third day.

BLOOD VOLUME DETERMINATIONS

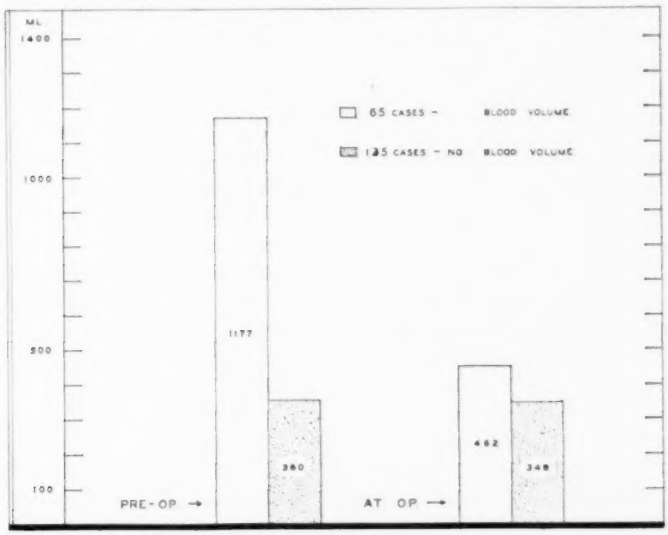
Sixty-five of the cases were evaluated preoperatively[6] with blood volume calculations by the T-1824 dye method and the results used as a guide for replacement. There were nine deaths in this group, giving a mortality of 13.84%. In the remaining cases there were 190 of comparable nature surgically but in which no blood volume studies were done and preoperative therapy was based on the usual routine laboratory data such as blood counts. The mortality was 17.4%, with 33 deaths. One of the deaths in the blood volume group, from esophageal resection,

6. (*a*) Beling, C. A.: Morton, T. V., Jr., and Bosch, D. T.: Blood Volume and Other Determinations in Preoperative and Postoperative Care, Surg., Gynec., & Obst. **87**:163-171 (Aug.) 1948. (*b*) Beling, C. A.: Bosch, D. T., and Morton, T. V., Jr.: Blood Volume Determinations in Surgery, Surg., Gynec., & Obst. **90**:686-696 (June) 1950.

has no counterpart in the second group, and when it is eliminated from comparison the mortality drops to 12.5%. While this difference in mortality is suggestive, the blood volume series is too small for proper comparison and the results are not significant. Further study is indicated and is being pursued.

Morbidity, also, was lessened in the blood volume group, whose average postoperative hospital stay was 15.9 days, as compared with 18.4 days. These patients were confined to bed for an average of 3.6 days, as compared with 4.6 days.

The most interesting finding in this study was the amount of blood given when based on measurement of blood volume as contrasted with the amount given to the other patients. Three hundred patients received no blood whatever. One hundred thirty-five received varying amounts predicated on routine laboratory tests or



Blood replacement per case.

guesswork. The remaining 65 were afforded quantitative repletion based on actual determination of blood volume deficits. Fifty-nine of the blood volume group received blood preoperatively, as contrasted with 61 of the second group of 135. The same group of surgeons handled all 500 cases so that individual judgment and conscientiousness are not major factors in this discrepancy. Rather, the surgeons were misled by presumably normal hemoglobin and red blood cell counts. As we have demonstrated previously,[6a] no true correlation exists between hemoglobin grams per 100 ml. and the total circulating hemoglobin mass or between the hematocrit and the circulating hemoglobin deficit. Similarly, there is no correlation between plasma protein grams per 100 ml. and the total circulating plasma proteins or plasma protein deficit. The concentration values commonly available on the chart are significant only when the blood volume, including all its components, is

normal. Calculations of total blood volume, plasma volume, circulating hemoglobin, and circulating protein deficits are the only satisfactory bases for accurate replacement.

The 65 patients in the blood-volume group were given a total of 76,500 ml. of blood (1,177 ml. per case) whereas the remaining 135 received 48,600 ml. (111.7 ml. per case) before surgery. During operation and in the immediate postoperative period (Figure) the former group received a total of 48,600 ml. (462ml. per case) of blood to replace operative loss and the latter group were given 83,500 ml. (348 ml. per case). Each patient in the blood-volume group received during and immediately after operation the amount of blood needed to cover operative loss. In the second group the blood given preoperatively per case was far from sufficient and the amount given at operation was scarcely enough to cover operative loss.

Our findings show that practically all elderly persons who come to surgery are victims of significant blood-volume deficits. Most of them require quantitative replacement to establish optimum surgical tolerance

COMMENT

Our review of 500 cases affords optimism in the surgical management of the elderly patient. Certainly no patient should be denied curative surgery solely because of age. When a curable disease exists, elderly persons make excellent postoperative recoveries provided that they have been properly prepared. In comparison to younger persons, they tolerate surgery well if preoperative restoration of normal blood volume is assured. Frequently patients can correct nutritional deficiencies and volume deficits by adequate dietary management in the weeks before operation, but in most cases such a long period is not granted to the surgeon and relatively rapid preparation becomes necessary. Human serum albumin may be substituted for blood or plasma but does not contain the needed erythrocytes. When whole blood is available, it is the material of choice. When accurate blood-volume studies are made, the deficits of the various components can be replaced by whole blood, plasma, or washed cells. Once the circulating blood volume has been returned to normal, the hematocrit and red cell count are valuable guides in maintaining the patient's status.

The following improvements in the management of the elderly surgical patient are suggested by this study:

1. The adoption of an optimistic approach. The elderly can and do make excellent recoveries from surgery when handled properly. They should not be allowed to continue without treatment until their disease has become irreversible. A great many more old persons will be salvaged by early investigation and definitive therapy regardless of age.

2. The presence of concurrent disease, such as a cardiac disorder, does not create an unsurmountable risk. More cooperation between internist and surgeon should result in better management.

3. Infection remains a problem regardless of antibiotic therapy. Elderly persons tolerate infection poorly. All precautions to avoid infection should be observed and specific antibiotic therapy instituted whenever possible.

4. Quantitative repletion based on preoperative blood-volume studies decreases morbidity and mortality and should be performed routinely.

SUMMARY

A review of 500 consecutive patients 60 years of age or older who were subjected to major surgery is presented. Forty-four per cent of the patients had some form of major surgery prior to the present study. The over-all mortality was 9.6%, with 48 deaths. The mortality among patients with preexisting disease other than their surgical condition was 12.3%, as compared with 6.6% among those patients free of concurrent disease. After 70 years of age the mortality increased from 5.41% to 16.1%. The mortality was not appreciably altered by the type of anesthesia employed. Of those dying, 58% had malignant disease. Mortality and morbidity are lessened by proper preoperative care, which should include blood-volume determinations and quantitative repletion.

NEW REGIMEN IN FEEDING THE CRITICALLY ILL

Preliminary Report

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PHASES of the problem of restoring and maintaining nutrition in the sick patient have been the subject of investigation at the Medical Research Foundation of Dade County during the past four years. Intermittent intravenous and enteral feedings have been considered, and as a result of our studies it is apparent that continuous-drip feeding solutions containing an excess of amino acids and calories administered by tube into the gastrointestinal tract provide the best means for restoring and maintaining nutrition. Herein are reported details of the successful solution of certain problems confronting patients who cannot or will not eat.

BACKGROUND

Limitations imposed on attempts to maintain nutrition by intermittent intravenous administration of nutrient solutions redirected our efforts to the gastrointestinal tract. The important basic observation of Elman [1] that incomplete mixtures of amino acids cannot be utilized in the synthesis of body protein even when the missing essential amino acid is provided six hours later emphasized the necessity for feeding complete protein or all essential amino acids. Cox and Mueller [2] showed that in spite of feeding protein of good quality synthesis may not be maintained and that variations in rate of protein hydrolysis and in the absorption and utilization of amino acids may be responsible for the failure to build body protein. The work of Cannon and others [3] established the fact that essential amino acids must be available simultaneously for cell anabolism. These workers concluded that amino acids are not stored in the body for "much longer than an hour." These basic facts suggest that intermittent feeding, oral or intravenous, would not be the method of choice in meeting the nutritional requirements of the sick patient. In addition, it

From the Medical Research Foundation of Dade County, Inc.

1. Elman, R.: Time Factor in Retention of Nitrogen After Intravenous Injection of a Mixture of Amino-Acids, Proc. Soc. Exper. Biol. & Med. **40**:484, 1939.

2. Cox, W. M., Jr., and Mueller, A. J.: Serum Albumin Regeneration as Effected by Intravenously and Orally Administered Protein Hydrolysates, J. Clin. Invest. **23**:875, 1944.

3. Cannon, P. R.; Steffee, C. H.; Frazier, L. E.; Rowley, D. A., and Stepto, R. C.: The Influence of Time of Ingestion of Essential Amino Acids upon Utilization in Tissue-Synthesis, Federation Proc. **6**:390, 1947.

was reasoned that the processes of protein metabolism were continuous day and night and that the demand for amino acids, particularly in sick patients, was therefore also continuous. We set forth to provide the critically ill patient continuously a mixture containing an excess of essential amino acids and calories and the necessary fluid and electrolytes to meet his demand.

METHODS

1. *Enteral Tube.*—The feeding regimen required that a tube be introduced into the upper gastrointestinal tract through the nose and that it be tolerated in this position for the period during which continuous feeding was required. Mucosal irritation associated with conventional rubber intubation tubes prevented their continuous use. We devised a small semirigid plastic tube with an external diameter of approximately 3 mm. which could be readily introduced through the nose into the stomach or duodenum. This tube has been well tolerated, even when left in place for as long as three months without change. Irritation has been minimal, and no serious sequela has been encountered.

2. *Characteristics of Feeding Solutions.*—A. Sterility: Sterility of the feeding solutions is required in order that they may be stored for long periods without deterioration so that they may be readily available. In addition, the solutions are given at rates requiring 8 to 12 hours per bottle. Contamination during this time may give rise to bacterial growth causing deterioration of the solutions and untoward reactions in the patient. The feeding solutions are an excellent growth medium for ordinary contaminants.

B. Stability: Since the development of precipitates in solutions at ordinary storage temperatures may be confused with contamination, it is required that the solutions be clear. Furthermore, it is required that the nutritive value of the solutions not be diminished during storage periods.

C. Viscosity: Fluids must be relatively thin and of low viscosity so that they may be administered at a constant rate without clogging the tube. The formulas described below meet these requirements and were administered by gravity alone. Rates were adjusted by the use of drip arrangements similar to those used for giving intravenous fluids.

D. Tolerance: The occurrence of nausea, vomiting, and diarrhea from feeding "kitchen" formulas and, in our early experience, with various types of balanced solutions emphasized the need of eliminating factors which give rise to undesirable gastrointestinal reactions. Solutions used in the past 16 months, which are the basis for this report, are unusually free of substances which give rise to nausea, vomiting, or diarrhea. The fluids are well tolerated because of (1) the quality of the nutritive ingredients, (2) the method of processing, including sterilization by filtration rather than by heat, and (3) the relatively slow rate of administration.

E. Nutritive value: It is required that the formulas provide daily (1) an excess of amino acids from the protein hydrolysate, (2) carbohydrate, not less than two parts to one part of protein, (3) the daily requirement of water, (4) adequate amounts of electrolytes and trace amounts of minerals based on their presence in milk, (5) approximately 4 to 6 gm. of sodium chloride (unless edema contraindicates its use), and (6) ethyl alcohol as required to increase the caloric content. In addition, vitamins must be supplemented orally or parenterally.

Typical formulas are illustrated in Table 1. The defatted protein hydrolysate was prepared in our laboratories. It is essentially a mixture of peptones, proteoses, and polypeptides with smaller amounts of amino acids than present in the lactalbumin hydrolysate. This formula was well tolerated and is considered the formula of choice when stability is proved.

The basic arrangement of the formulas with regard to protein, carbohydrate, fluid, and electrolytes was adjusted according to the demands of the patient. Adjustments have been made to meet unusual needs such as in diabetes or edema. In addition, the amount and make-up of formulas were varied according to whether the feeding was the sole dietary intake or a supplement to other food. Ethyl alcohol was useful in increasing the caloric value of the solution and had desirable effects

TABLE 1.—*Composition of Typical Feeding Formulas, Approximate Grams per Liter*

	Lactalbumin Hydrolysate			Defatted Milk Hydrolysate
Protein	50.0	75.0	75.0	50.0
Carbohydrate	150.0	150.0	150.0	150.0
Calcium	0.7	0.7	0.7	2.0
Potassium	0.5	0.5	0.5	2.3
Phosphorus	0.5	0.5	0.5	1.5
Magnesium	0.1	0.1	0.1	0.1
Sodium chloride	Trace	2.0	2.0	2.0
Sodium lactate	....	1.5	1.5	?
Ethyl alcohol	....	....	20.0	....
Calories provided	800	900	1,050	800

TABLE 2.—*Age Distribution of Patients Fed*

Age, Yr.	0-4	5-14	15-24	25-34	35-44	45-54	55-64	65-74	75+	?	Total
No. of cases	4	4	22	18	31	53	42	43	36	1	254
Deaths	0	0	2	3	7	10	12	20	18	1	73

in patients requiring mild sedation. The details of the preparation of the feeding solutions will be reported elsewhere.

CLINICAL DATA

The regimen outlined above has been used in more than 500 patients during the past four years. Clinical data which follow have been assembled from the experience encountered in 254 patients at the Jackson Memorial Hospital during the past 18 months. It will be noted from table 2 that 69% of patients were over 45 years of age. The high mortality rate (28%) is an indication that patients fed were severely ill. Ages ranged from 7 months to 94 years.

Cases are grouped (Table 3) according to the indication for the use of the feeding regimen for convenience in analyzing the data. In Tables 4, 5, 6, and 7 the broad classifications are further divided to indicate the variety of conditions and illnesses affecting patients. It will be noted from these details that solutions were administered during periods varying from 1 to 214 days. Deaths occurring in each group involve those patients dying while on the feeding regimen. This high mortality emphasizes the severity of illnesses represented in this study.

TABLE 3.—*Analysis of Patients According to Indications for Feeding Regimen*

Disorder	No. of Cases	Average Days on Feeding
Cachexia	127	13
Coma	58	12
Excess catabolism	46	21
Mechanical or psychiatric	23	23
	254	14

TABLE 4.—*Cachexia—127 Cases (31% Mortality)*

Basic Disorder	No. of Cases	Days on Feeding		No. of Deaths
		Range	Average	
Malnutrition	31	1-68	16	14
Malignant disease	31	2-33	10	12
Nonmalignant tumors	3	6-63	28	0
Cardiac disease	18	1-151	17	7
Gastrointestinal condition	14	1-60	11	1
Pulmonary tuberculosis	14	1-35	14	2
Fractures, senility	7	2-36	9	3
Cirrhosis	5	5-25	11	1
Other conditions	4	3-18	5	0
	127	1-151	13	40

TABLE 5.—*Coma—58 Cases (38% Mortality)*

Basic Disorder	No. of Cases	Days on Feeding		No. of Deaths
		Range	Average	
Eclampsia	14	3-19	7	0
Head injury	16	1-37	18	3
Cerebral vascular	15	3-54	10	11
Brain tumor	9	9-62	25	7
Uremia	2	4-18	11	1
Epileptic	1	20	20	0
Syphilitic meningitis	1	5	5	0
	58	1-62	12	22

TABLE 6.—*Excessive Catabolism—46 Cases (15% Mortality)*

Basic Disorder	No. of Cases	Days on Feeding		No. of Deaths
		Range	Average	
Peritonitis, chronic suppurative	8	2-71	18	1
Inflammation, acute and chronic, nonsuppurative	7	7-19	11	1
Intestinal fistula	6	2-45	20	2
Burns, extensive	7	1-180	35	2
Ulcerative colitis	5	11-98	46	1
Hepatitis, acute	4	8-21	14	0
Nephrosis	3	5-28	16	0
Nephritis, chronic	2	1-9	5	0
Cirrhosis with ascites	1	22	22	0
Other	3	3-17	8	0
	46	1-180	21	7

TABLE 7.—*Mechanical and Psychiatric Conditions—23 Cases (49% Mortality)*

Basic Disorder	No. of Cases	Days on Feeding		No. of Deaths
		Range	Average	
Psychosis	6	4-15	9	1
Hiccough, coronary occlusion	1	12	..	0
Carcinoma				
Face	4	3-34	14	0
Larynx	3	2-35	15	2
Pharynx	1	29	..	0
Esophagus	2	7-41	24	2
Stomach	1	5	..	0
Obstruction	3	3-7	6	0
Radiation necrosis	2	49-214	131	0
	23	2-214	23	9

Within the limits of this paper the following selected case reports best convey the value of this method of feeding.

REPORT OF CASES

CASE 1.—D. D., a 35-year-old white man for eight years a paraplegic as a result of a gunshot wound, was admitted to Jackson Memorial Hospital on Dec. 4, 1950. He was markedly malnourished and dehydrated. He had extreme anorexia, was despondent and uncooperative. He suffered with multiple infected decubitus ulcers, urethritis, and cystitis resulting from an indwelling catheter. The serum protein level was 4.9 gm. per 100 ml., and his weight was estimated to be 110 lb. (50 kg.). The regimen of continuous tube feeding was begun in April, 1950, after unsuccessful attempts to provide nutrition and fluid requirements by oral and parenteral routes. After the patient's mental attitude had been overcome during the first two days, it was possible on the third day of feeding to increase the formula to 3,000 ml. daily, which provided 225 gm. of protein and approximately 2,700 calories. Clinical improvement was rapid, and after three weeks of this regimen the patient's appetite was restored, so that in addition to the formula he ingested regular hospital meals. After three months the patient had gained approximately 40 lb. (18.1 kg.) and serum protein determinations were consistently normal. There was a rapid clearing of the cystitis, and the decubitus ulcers were greatly improved.

Comment.—Anorexia apparently due to amino-acid deficiency [4] results in further protein depletion of malnourished patients. A normal appetite usually develops in such patients while they are receiving the tube formula. Many will eat the full hospital diet while taking up to 3 liters of formula daily. Routine supplemental tube feeding by this method in early paraplegia should combat the development of hypoproteinemia and favor early convalescence.

CASE 2.—G. C., a 42-year-old white man with advanced pulmonary tuberculosis and severe malnutrition, was admitted to the Dade County Hospital on Sept. 10, 1949. Because of his inability or unwillingness to eat the high caloric hospital diet, intermittent "kitchen" formulas were given. The patient did not tolerate these feedings because of frequent nausea, vomiting, and diarrhea. He was unable to maintain his weight, and two months after his admission continuous intraduodenal drip feeding through the plastic nasal tube was begun and continued for two months. He received 3 liters daily, providing 225 gm. of amino acids and approximately 2,700 calories. Clinical improvement was evidenced by an early rapid weight gain. Within a few weeks he was also taking, in addition to the tube feeding, the regular hospital diet, and within two months had gained 35 lb. (16 kg.).

Comment.—Thirty-five patients with pulmonary tuberculosis have been given formulas as supplemental feeding during the past four years, some taking as little as 1 liter with a gain in weight and improved appetite.

CASE 3.—B. F., a 49-year-old white man, was admitted on Jan. 9, 1951, with extensive second and third degree burns. Burned areas became infected, and drainage was profuse. He was toxic, mentally confused, dehydrated and emaciated. He would not eat. Veins were not accessible because of the extensive burns. Nutritional fluid and electrolyte requirements of this patient could not be provided by oral or parenteral methods. A feeding regimen consisting of 3 liters providing 225 gm. of protein and 2,700 calories per day was begun on the 14th day. Feeding was continuous for six months, during which time skin grafts and reconstructive surgery were successful.

Comment.—Supplemental tube feeding of "kitchen" formulas has been used in burned patients for many years. The simplicity of gravity feeding through narrow

4. Youmans, J. B., and Patton, E. W.: Nutritional Deficiencies, Philadelphia, J. B. Lippincott Company, 1941, p. 231.

plastic nasal tubes and the stability of the formulas have many advantages. We have adopted this method for routine supplemental or total feeding in seriously burned patients in order to furnish their protein requirement. This patient was given as much as 360 gm. of protein daily for several days without untoward reaction; however, the need for this amount of protein is not established. It is of interest that such large amounts of protein may be tolerated.

CASE 4.—R. F., a 20-year-old white man, was first admitted to a hospital elsewhere on July 5, 1950, with an intracranial injury, basal skull fracture, and a compound fracture of the left femur resulting from a motorcycle accident. Two weeks later he was transferred to Jackson Memorial Hospital in coma, with severe dehydration, hypoproteinemia, and draining decubitus ulcers. The serum protein level was 5.98% (albumin, 3.18, and globulin, 2.80).

Continuous drip feeding was begun immediately, using 3 liters, which furnished 150 gm. of protein and 2,400 calories daily. He was more alert the following day and two days later responded to questions. On the fourth day restraints were removed, and he recognized and visited with friends. The serum protein level on the fourth day had fallen to 5.4 gm. per 100 ml. (albumin, 2.96, and globulin, 2.44), indicating a previous hemoconcentration. The formula was continued, increasing to 225 gm. and 2,700 calories daily until the 12th day, when a regular diet was resumed. The serum protein level was 6.5 gm. per 100 ml. (albumin, 3.53, and globulin, 3.01).

Comment.—We have seen rapid clinical improvement in many comatose patients including those who have had cerebrovascular accidents and those with head injuries. As in this case, many have severe dehydration and electrolyte imbalance, which is readily and safely corrected by this method. They cannot take food normally, and intravenous alimentation is not considered desirable. We believe that many unconscious patients die from fluid, electrolyte, and nutritional disturbances rather than from the injury or lesion rendering them unconscious. If properly sustained, more patients will survive their intracranial injury. For example, a 62-year-old white woman in coma for five months has been maintained in an excellent state of nutrition by continuous drip feeding and is now taking small feedings by mouth.

CASE 5.—J. A., a 46-year-old white man, was admitted to the hospital on Nov. 26, 1950, with a duodenal ulcer. A subtotal gastrectomy was performed, and on the second postoperative day a duodenal fistula developed. The drainage became profuse, loss of fluids and electrolytes was marked, and severe dehydration and malnutrition developed in spite of parenteral alimentation. Biochemical and nitrogen balance studies revealed marked abnormalities.

A lead-shot-weighted string was swallowed and passed into the distal jejunum through the gastrojejunal anastomosis. When the position was verified by x-ray examination, the string was attached by catgut to the plastic nasal tube brought out through the mouth. With the tube thus introduced into the jejunum, continuous drip feeding was begun first with 1,000 ml. and increased to 3,000 ml. the following day. The 225 gm. of protein intake resulted in rapid positive nitrogen balance and a 6 lb. (2.7 kg.) weight gain in two weeks. The original serum protein level of 5.89 gm. per 100 ml. was increased to 7.37 gm. (albumin, 4.56, and globulin, 2.89). The fistula closed, and the patient was discharged on the 28th day.

Comment.—Five postgastrectomy duodenal fistulas in local hospitals have been treated by this simple method and all closed spontaneously in three to seven weeks.

CASE 6.—W. B., a 24-year-old white man, was admitted to the hospital on April 19, 1951, with chronic ulcerative colitis of three years' duration. He was suffering with intestinal perforation, localized peritonitis with purulent drainage, and a fecal fistula. He had been having 10 to 20 liquid bowel movements daily. There was marked dehydration and toxemia. His weight was 97 lb. (44 kg.), and the serum protein level was 5.8 gm. per 100 ml.

Continuous feeding of a formula using 2 liters providing 150 gm. of protein daily and later 3 liters providing 225 gm. of protein was continued for two and a half months. Nitrogen balance was restored, and clinical improvement was noted early in spite of continuing frequent stools. He gained 18 lb. (8.2 kg.), exceeding his previous maximum weight. The formula was continued as supplementary feeding beyond the period of postoperative colectomy.

Comment.—Five patients with chronic ulcerative colitis were prepared for colectomy in this manner. In two cases there was a definite decrease in the number of daily stools. All patients gained weight rapidly, and, in spite of the apparently hopeless outlook for two on their admission, all were prepared for surgical procedures.

Case 7.—A. A., a 45-year-old Negro woman, was admitted to Jackson Memorial Hospital on Oct. 24, 1950, with extensive radiation necrosis of the mandible resulting from repeated therapy for carcinoma of the lower lip of eight years' duration. She was extremely emaciated, her admission weight being 103 lb. (46.7 kg.). Tube feeding was begun on November 7 to prepare her for mandibulectomy and to maintain nutrition during the multiple stages of reconstructive surgery. After nine months of maintenance on this regimen, she had undergone several operative procedures and had gained 32 lb. (14.5 kg.). Because of her concern about weight gain, the formula was reduced from 3 liters daily providing 75 gm. of protein per liter to 3 liters providing 50 gm. per liter.

Comment.—In this case, as in others with major maxillofacial and pharyngeal lesions requiring surgery, long-term feeding arrangements were necessary. The patient received, as her only source of nutrition, the continuous-drip feeding by plastic nasal tube for nine months, for three months of which a single tube was left in place without change. The solutions and plastic tubes have been well tolerated. We have tested many formulas in our research program on this very cooperative patient. Results of repeated nitrogen balance studies conformed to the progressively improved clinical picture.[5]

COMMENT

A four-year study of the nutritional management of over 500 critically ill patients has been presented.

A new regimen has been developed, based on the newer knowledge of the utilization of amino acids for protein metabolism. It provides, at a constant rate of administration, amino acids and other nutrients to meet the continuing and often excessive demands of the sick patient. This regimen consists of balanced, stable, nutrient solutions fed at a continuous and constant rate through a small, well-tolerated tube inserted into the gastrointestinal tract. The content and a brief description of the preparation of the solutions have been presented.

Data assembled from 254 patients fed by this regimen have been presented, with illustrative case reports. The average duration of feeding has been 15 days. The adult patient has received an average daily intake of 2,500 cc. of formula containing from 125 to 200 gm. of protein and providing approximately 2,000 calories per day. The longest continuous period of feeding by this regimen was 214 days. This patient had a true weight gain of 32 lb. (14.5 kg.).

5. This patient has now been on the feeding regimen for 450 days. She has shown a total weight gain of 45 lb. (20.4 kg.). There is no clinical evidence of dietary deficiency, and laboratory studies of the hemoglobin, red blood cell count, and blood chemistry, including the blood cholesterol and other lipid elements, show normal values.

SUMMARY

The regimen described has restored and maintained the desired nutritional status in critically ill patients more effectively than other methods of feeding. It is simple to administer to patients in whom the gastrointestinal tract is available for feeding, and it is extremely well tolerated. Continuous drip feeding of partially hydrolyzed protein appeared to meet the demands of continuous protein metabolism. Nutrient solutions have been prepared in a sterile and stable form. They can be stored at ordinary temperatures for long periods without deterioration. This method of nutritional management has unusually broad applications, especially when prolonged feeding is required for institutional and home care of the critically ill.

PALLIATIVE THERAPY WITH FRACTIONATED INTRA-ARTERIAL NITROGEN MUSTARD

Report of Its Use in a Case of Persistent Cancer of the Tongue with an Unusual Complication

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ASPINWALL, PA.
SALVADOR CASTANARES, M.D.
AND
GEORGE McALEESE, M.D.
PITTSBURGH

WITHIN the past year, increasing interest has developed in the palliation of various types of head and neck cancer by the intra-arterial injection of chemotherapeutic agents.[1] The patients treated were those in whom further surgical or irradiation therapy was no longer feasible, and in whom the persistent lesions were causing marked symptoms as the result of either the location of the lesion or the severe pain.

This case is reported because of the dramatic relief of the intense pain to demonstrate the histological effect of the chemotherapeutic agent on the tumor and its bed, to describe a hitherto unreported complication, and to suggest a method by which this complication might be eliminated in the treatment of future similarly selected cases.

REPORT OF CASE

The patient, a 63-year-old white man, was admitted to the hospital in March, 1950, with the complaint of pain along the left posterior margin of his tongue. The onset was two days prior to admission, the patient consulting his family physician, who advised immediate hospitalization. Examination showed an extensive tumor of the left middle and posterior thirds of the mobile portion of the tongue, extending into the floor of the mouth and the adjacent tonsillar pillar. There were no palpable lymph nodes or involvement of the mandible. The tumor was firm, slightly elevated, and flat and did not show ulceration. Biopsy disclosed a Grade II squamous-cell carcinoma. Roentgen irradiation therapy was first chosen, and 7,200 r was delivered through an intracavitary cone with low filtration over a four-week period. The patient tolerated the roentgen therapeutic procedure well, and three subsequent biopsy specimens showed no tumor cells. Three months after therapy and with evidence of eradication of the primary lesion, a left radical neck dissection was carried out, including resection of the lower portion of the parotid gland. The mandibular branch of the seventh cranial nerve was sacrificed. The pathological specimen showed tumor invasion of an aggregate of enlarged

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Reviewed in the Veterans Administration and published with the approval of the Chief Medical Director. The statements and conclusions published by the authors are the result of their own study and do not necessarily reflect the opinion or policy of the Veterans Administration.

1. Klopp, C. T., and others: Fractionated Intra-Arterial Cancer: Chemotherapy with Methyl Bis Amine Hydrochloride; A Preliminary Report, Ann. Surg. **132**:811, 1950.

cervical nodes. On follow-up examinations, no evidence of persistent tumor was found until the eighth month after therapy. At this time, a biopsy specimen of an ulcer at the base of the tongue disclosed persistent cancer. A second course of irradiation therapy was decided upon. At this time irradiation consisted of 5,585 r delivered through three ports: left lateral facial, right lateral facial, and left submaxillary ports. Subsequent to this therapy, the patient complained of persistent pain in the region of the original tumor. A biopsy specimen, taken two months following therapy, showed persistence of the squamous-cell carcinoma. The pain in the region of the primary lesion was persistent and increasing in severity. Larger and more frequent doses of opiates had to be given for control. After careful evaluation at this time, it was felt that neither surgical nor roentgenologic treatment had more to offer this patient. In view of this rather hopeless situation, it was decided to utilize the recently reported method of palliation in the form of fractionated intra-arterial administration of nitrogen mustard (methyl-*bis* or *tris* [β-chloroethyl] amine hydrochloride).[1]

This was undertaken four months after the patient's final course of irradiation therapy. The left superior thyroid artery was exposed, ligated distally, and cannulized with polyethylene tubing for the administration of the chemotherapeutic agent, methyl-*bis*(β-chloroethyl) amine

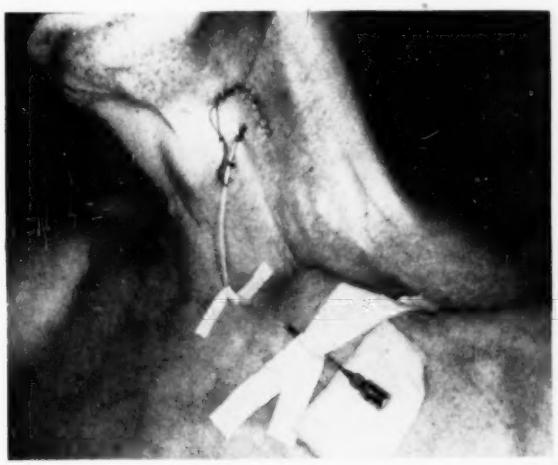

Fig. 1.—Photograph of patient with intra-arterial polyethylene tube in place.

hydrochloride (Figs. 1 and 2). At this time, the patient's general physical condition was good: his blood showed 4,220,000 red cells, 13 gm. of hemoglobin, and 8,200 white cells. His weight was 59 kg. It was calculated, therefore,[2] that the patient should receive a total dosage not to exceed 28 mg. of the nitrogen mustard (0.066 mg. per kilogram of body weight a day). A fractionated dose of 2 mg. twice a day delivered intra-arterially through the plastic tubing was chosen. At each administration of the drug, a fresh solution was prepared, the 2 mg. being contained in 2 cc. of solution. The tubing was irrigated with isotonic sodium chloride solution before and after each injection, followed by the instillation of 1 mg. of heparin. This was retained in the tubing at the completion of the procedure to prevent clotting and possible thrombosis. Daily complete blood counts made following this procedure showed no significant

2. Karnofsky, D. A.; Craver, L. F.; Rhoads, C. P., and Abels, J. C.: An Evaluation of Methyl-Bis (β-Chloroethyl) Amine Hydrochloride and Tris (β-Chloroethyl) Amine Hydrochloride (Nitrogen Mustards) in the Treatment of Lymphomas, Leukemia, and Allied Diseases, in Approaches to Tumor Chemotherapy, edited by F. R. Moulton, Washington, D. C., American Association for the Advancement of Science, 1947, p. 319. Roswit, B., and Kaplan, G.: The Role of Nitrogen Mustard (HN_2) as a Systemic Adjunct to Radiation Therapy in Malignant Diseases, to be published.

variation. Forty-eight hours after the first injection, the patient stated that he had little pain. The use of opiates was discontinued, and placebos were substituted. This freedom from severe pain and need for opiates persists to the present (Fig. 3). After the tenth injection (which brought the total of nitrogen mustard given intra-arterially to 20 mg.), transient right hemiparesis was noted which lasted approximately 20 minutes after the injection. On the following morning, and just prior to the usual 2-mg. injection of the chemical agent, the patient had a right-sided convulsive seizure which lasted approximately three minutes. This was followed

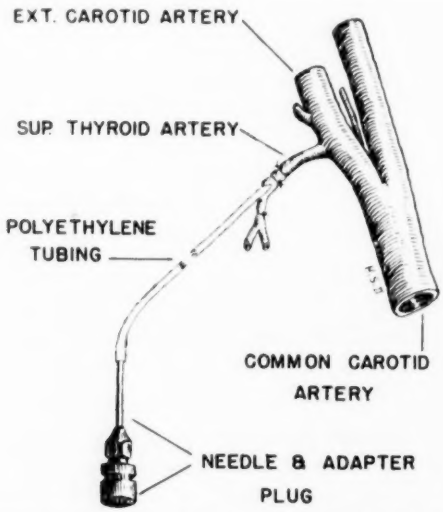

Fig. 2.—Diagrammatic representation of tube placed proximally into superior thyroid artery

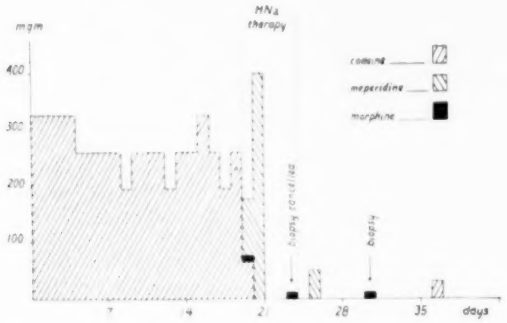

Fig. 3.—Chart showing opiate requirements for control of pain in patient before and after nitrogen mustard (HN_2) therapy.

by another episode of temporary right hemiparesis and aphasia. In view of the severity of this complication, it was promptly decided to block the left stellate ganglion. This procedure resulted in marked immediate improvement. Because of the complication, it was thought advisable to discontinue further administration of the nitrogen mustard. Another similar seizure occurred two hours later and lasted three minutes. At this time, the polyethylene cannula was removed. A second stellate ganglion block was done, again with prompt beneficial effect. The patient had no further neurological difficulty and regained complete use of his extremities.

COMMENT

In the review of this case, one is immediately struck by the rapid relief of pain following the onset of therapy. This relief from pain has persisted three months to the present and has been accompanied with an improvement in the patient's affect and his attitude toward his illness. At the time that therapy was instituted, this patient was considered a borderline drug addict. At the completion of therapy, there was no desire for drugs on his part. The effect of the two convulsive seizures

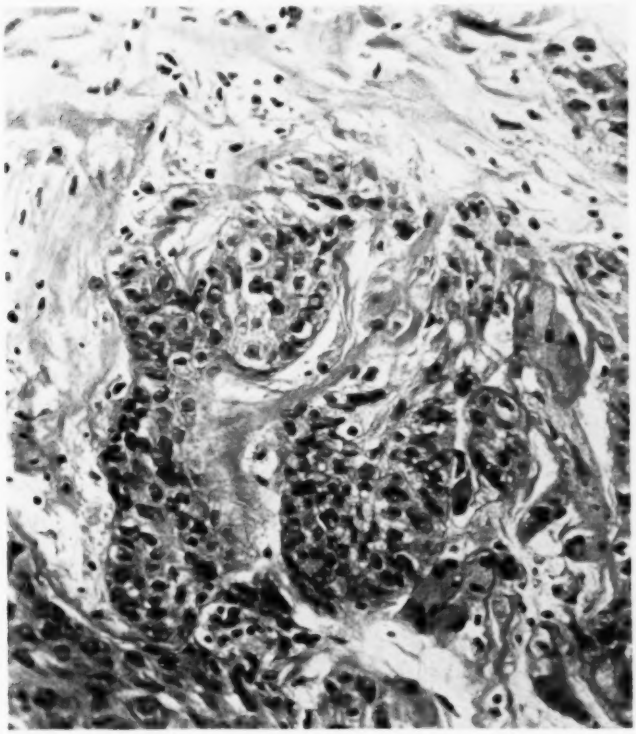

Fig. 4.—Biopsy specimen taken before nitrogen mustard therapy, demonstrating persistent squamous-cell carcinoma.

on the patient's general mood and behavior changes is naturally open to question. The patient is right-handed.

In this case, although the nitrogen mustard therapy was not carried to the maximum of the calculated dosage, there was no appreciable generalized systemic reaction to the drug in the form of anemia or leucopenia. It is of interest, however, that in the biopsy specimen taken immediately prior to the onset of therapy, viable tumor cells were obtained. During the course of therapy, evidence of tissue reaction of the type described by Klopp [1] was seen in the skin, buccal mucous membrane, and tongue following the general distribution of the external carotid artery on the left side of the face and neck. After therapy, biopsy specimens taken from the site

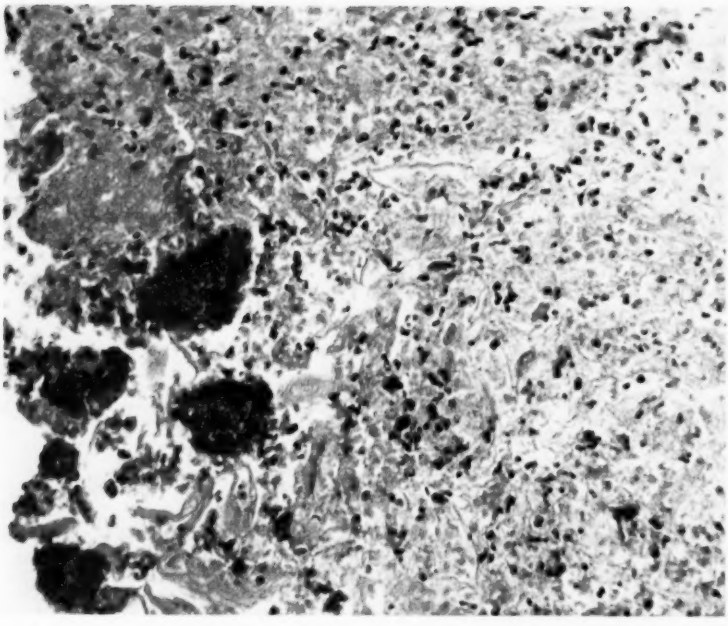

Fig. 5.—Biopsy specimen taken immediately after nitrogen mustard therapy, revealing typical radiation-like reaction with destruction of tumor.

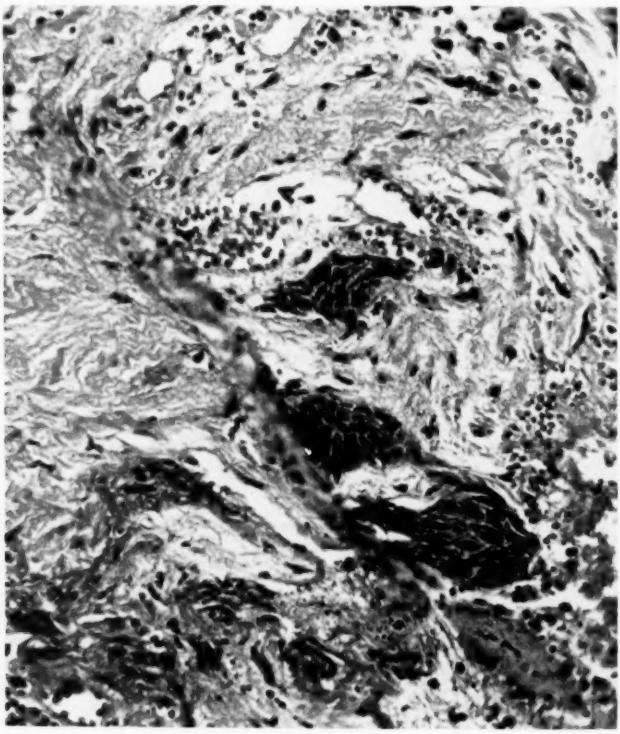

Fig. 6.—Biopsy specimen taken 10 weeks after nitrogen mustard therapy, demonstrating persistent viable tumors.

of the primary lesion were negative for persistent cancer, until the periodic biopsy specimen removed 10 weeks after nitrogen mustard therapy once again revealed persistent tumor. It would be of interest to speculate on the full effect of the chemotherapy, had the complication previously mentioned not intervened.

Because of the transient nature of the complication, it was felt to be on the basis of a transient cerebral vasospasm. Whether this vasospasm was caused by the presence of an intra-arterial foreign body, the indwelling catheter, or was the result of the injection of the irritant, therapeutic agent, or was due to both factors, cannot be ascertained. However, we definitely feel that the intra-arterial injection of nitrogen mustard should be followed by the injection of a small quantity of saline solution (4 or 5 cc.), followed by administration of a small amount of heparin solution. We feel then that should vasospasm take place, there is at least temporary protection by the locally applied heparin from the development of thrombosis following the vasospasm. In the future treatment of similar patients, we suggest that just prior to each injection of nitrogen mustard the patient be further protected by means of a cervical sympathetic nerve block. This could be accomplished by means of either one or repeated injections of procaine solution or the continuous type of nerve block.

In the accompanying photomicrograph is demonstrated the histologic character of the persistent squamous-cell cancer (Fig. 4) before therapy was instituted. Figure 5 represents the radiation-like response of the area under treatment at the height of the reaction. Note the destruction of the tumor cells, with the edema and inflammatory reaction in the tumor bed. In Figure 6, the persistent tumor cells are again demonstrated and the inflammatory response has subsided.

SUMMARY

This report presents the case of a man who, after two full courses of roentgen-ray therapy, had a persistent primary cancer of the base of the tongue on the left which had extended to involve the mandibular ridge and the tonsillar pillar, and in whom the symptom of pain had developed to the point that it had become intolerable. After therapy with fractionated intra-arterial doses of nitrogen mustard (methyl-*bis*[β-chloroethyl] amine hydrochloride), the painful symptoms were completely relieved. The improvement in mood or psychological affect which may be the result of the treatment or which may have been brought about as a sequela of the cerebral vasospasm in this patient is also worthy of note. This cerebral complication, though transient, represents a marked hazard in the treatment of other patients. It is suggested that this hazard may well be minimized or perhaps completely eliminated by preliminary procaine block. The serious toxic effects of damage to blood-forming tissue, as reported by some in the intravenous method of therapy with nitrogen mustard, did not take place in this case with the intra-arterial route of therapy.

The results obtained in this patient from the standpoint of palliation seem entirely worth while and justify the application of this method to other similar cases. Whether this approach to such lesions will prove to be a valuable adjunct to the roentgen-ray therapy remains an open question, but one certainly worthy of further investigation.

Ellis Fischel State Cancer Hospital, Columbia, Mo. (Dr. Schwarz).

ACROMIOCLAVICULAR DISLOCATION TREATED BY TRANSFERENCE OF THE CORACOACROMIAL LIGAMENT

JULIUS S. NEVIASER, M.D.
WASHINGTON, D. C.

ACROMIOCLAVICULAR dislocation has been a difficult lesion to treat by conservative means. After reduction of a dislocation, various forms of strappings, splints, plaster spicas, and braces have been advocated. After external fixation the joint remains in partial or complete separation in many cases. This results, either early or late, in pain and limitation of motion in the shoulder or in an obvious deformity which is objectionable, particularly to women. Many operative procedures have been published, the most popular of which are internal fixation of the joint by wire or screws, coracoclavicular screw fixation, arthrodesis, and resection of the outer end of the clavicle. Each has certain disadvantages. As the clavicle rotates on its long axis with abduction of the arm, any fixation of the acromioclavicular joint will limit abduction of the shoulder. Inman and Saunders [1] state that with loss of clavicular rotation, abduction is limited to approximately 120 degrees. Urist [2] points out that excision of the outer end of the clavicle results in early fatigue or in slight weakness of the shoulder on prolonged vigorous exercise. The affected shoulder is slightly lower than the intact shoulder as the scapula falls forward and lower on the thorax. Inman and Saunders found that minor instability occurred when the patient supported a weight overhead in their cases of excision of the clavicle.

The following operation tends to restore the clavicle to its normal position and holds it in place by providing a new superior acromioclavicular ligament through the transference of the coracoacromial ligament. By this procedure full stability of the joint is maintained, with no loss of motion at the acromioclavicular joint. A slightly curved incision begins over the outer half of the clavicle at its anterior border and is extended to the outer border of the acromion. The deltoid muscle is then stripped from the anterior lateral third of the clavicle. Exposure of the coracoacromial ligament as well as the acromioclavicular separation is made. The dislocation is reduced without making any attempt to repair the torn or frayed ligaments at the acromioclavicular joint. The reduction of the dislocation is held by a Kirschner wire, with a diameter of 1/16 (0.062) in. (2.7 mm.) passed through the skin and acromion into the clavicle. To prevent the wire from working loose, we place it so that it is fixed through the outer cortex of the clavicle near the apex of the lateral curve. The coracoacromial ligament is removed from the coracoid

Read before the Section on Orthopedic Surgery at the One Hundredth Annual Session of the American Medical Association, Atlantic City, June 13, 1951.

1. Inman, V. T., and Saunders, J. B. deC. M.: Observations on the Function of the Clavicle, California Med. **65**:158-166 (Oct.) 1946.

2. Urist, M. R.: Complete Dislocations of the Acromioclavicular Joint, J. Bone & Joint Surg. **28**: No. 4, 813-837 (Oct.) 1946.

attachment through osteotomy of a small portion of its broad base at the lateral border of the coracoid process. This strong broad ligament is then turned over on the acromion and fixed by three catgut sutures, each passed through the tough fascial tissue on the superior surface of the acromion. After fixation on the acromion the ligament is brought over the acromioclavicular joint onto the superior

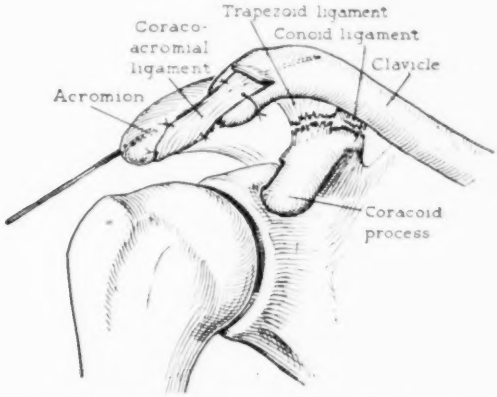

Fig. 1.—Transference of coracoacromial ligament. Note Kirschner wire holding clavicle in position.

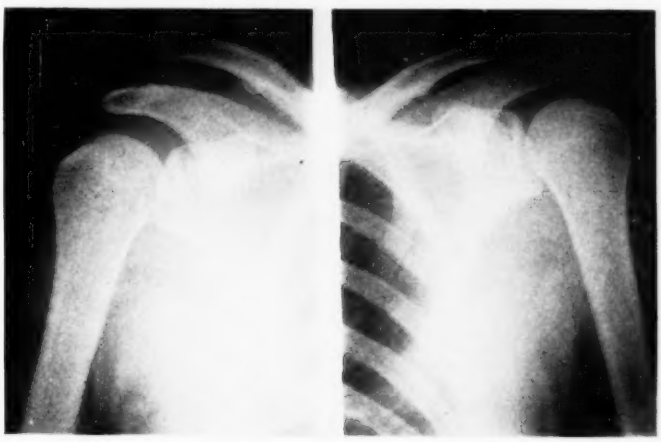

Fig. 2.—Acromioclavicular dislocation of right shoulder. Left shoulder is normal.

surface of the clavicle where it is to be anchored. First, a small lip of bone is lifted from the superior surface of the clavicle, or this area may be roughened. The latter technique is the one that we now employ. Two vertical drill holes are made in the clavicle at this site, and the ligament is sutured to the clavicle by catgut sutures which are passed through these drill holes (Fig. 1). Before suturing, every effort is made to follow the course of the normal ligaments of the acromioclavicular joint

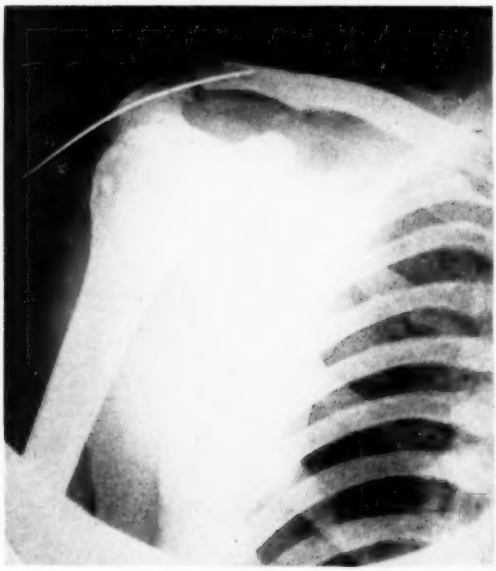

Fig. 3.—Dislocation reduced and clavicle held in position by a Kirschner wire.

Fig. 4.—Reduction maintained seven months after operation. Note slight calcification of the trapezoid and conoid ligaments.

and the small bony attachment from the coracoid process is made to lie flat on the roughened surface of the clavicle. The deltoid muscle is then sutured back on the clavicle. After closure of the wound with silk, the Kirschner wire is cut off about 1 cm. from the skin surface and covered by a small felt pad held by adhesive. The arm is now strapped to the side. The wound is dressed and the protruding wire inspected every week. Slow passive motion of the shoulder is performed at these inspections to prevent restriction of motion in the joint from inactivity. The wire is removed about five weeks after operation. By this time it is felt that the transferred coracoacromial ligament has healed sufficiently to maintain the clavicle in its proper position. Now the patient is encouraged to exercise the arm and permitted to be active or to return to work after six weeks.

Fig. 5.—Appearance of the acromioclavicular joint with the arm in abduction and external rotation.

COMMENT

Fourteen patients with complete dislocation of the acromioclavicular joint were operated on. Seven had the dislocation two weeks or longer before surgery was done, and in seven it was of recent occurrence. The end-results were considered good or excellent if the patient had correction of the dislocation, no discomfort, and good shoulder motion with abduction ranging from 160 to 180 degrees. This result occurred in 13 cases of our series. An analysis of these cases revealed two significant findings at operation. There were torn or completely ruptured acromioclavicular and coracoclavicular ligaments found in every case. In five cases calcification in and about the trapezoid and conoid ligaments was found (Table). It is a known fact that calcification may appear whether the dislocation is mild or severe and whether the treatment is conservative or surgical. This calcification is regarded as part of the healing process of the ligaments and does not interfere with the function of the shoulder unless there is actual fusion between the clavicle and the scapula through marked ossification of the ligaments and soft tissues between these two bones. This fusion occurred in one case, and there was abduction to only 135 degrees, although the patient had no pain. One case revealed some ossification of the scar tissue about the acromioclavicular joint.

Analysis of Operative Cases in Which the Treatment Was Transference of the Coracoacromial Ligament

Case	Sex	Age	Shoulder	Occupation	Interval Before Surgery	Operative Findings	Wire Removed	End-Result	Last Roentgenographic Findings
1	M	54	Right	Carpenter	6 days	Torn coracoclavicular ligaments	25 days	Function good; abduction 170 degrees; returned to work in 6 weeks	Slight irregularity of the inferior surface of clavicle at the outer end of this bone
2	M	34	Right	Porter	7½ weeks	Torn coracoclavicular ligaments	5 weeks	Function good; abduction 160 degrees; returned to work in 2 months	Slight irregularity of the clavicle at the acromioclavicular joint
3	F	29	Right	Housewife	16 days	Some calcification of the coracoclavicular ligaments	32 days	Function excellent	Some excess bone formation under the outer portion of the clavicle; small calcified mass just above the acromioclavicular joint
4	F	34	Left	Housewife	3 days	Torn coracoclavicular ligaments	5 weeks	Function excellent	No changes
5	F	48	Right	Housewife	8 weeks	Frayed and torn coracoclavicular ligaments	3½ weeks	Excellent range of motion; has no complaints	Some irregularity of the acromion at the acromioclavicular joint
6	M	19	Left	Student	45 days	Torn coracoclavicular ligaments with some ossification	1 mo.	Function good; played football after 6 weeks	Some calcification just below the outer portion of the clavicle; slight ossification of the coracoclavicular ligaments
7	M	23	Left	Sheet metal worker	3 days	Complete rupture of the coracoclavicular ligaments	5 weeks	Function good; returned to work in 2 months	Small lip of bone on the superior surface of the clavicle where ligament was inserted
8	M	58	Right	Presser	8 days	Calcification of the coracoclavicular ligaments	5 weeks	Function fair; used cane because of fractured left leg	Marked calcification of coracoclavicular ligaments; drill hole seen through the acromion
9	M	24	Right	Maintenance man	6 weeks	Marked calcification of coracoclavicular ligaments; scar tissue formation at acromioclavicular joint with some ossification	1 mo.	Function excellent; returned to work in 7 weeks	Some calcification of coracoclavicular ligaments
10	M	24	Right	Carpenter	4 weeks	Calcification of coracoclavicular ligaments	5 weeks	Function good; used crutches because of fracture of right tibia	Some irregularity at the distal end of the clavicle; calcification of coracoclavicular ligaments
11	M	28	Right	Clerk	1 day	Complete rupture of the acromioclavicular and coracoclavicular ligaments	4½ weeks	Function excellent	Small area of calcification at the distal end of clavicle inferiorly; some calcification of coracoclavicular ligaments
12	M	22	Right	Student	2 days	Complete rupture of the acromioclavicular and coracoclavicular ligaments	4½ weeks	No complaints; abduction 170 degrees	Slight calcification of coracoclavicular ligaments
13	M	49	Left	Laborer	24 days	Frayed and torn coracoclavicular ligaments	1 mo.	Function good; no complaints	Drill hole noted in the lateral portion of the clavicle
14	M	33	Right	Mechanic	5 days	Complete rupture of the acromioclavicular and coracoclavicular ligaments	5 weeks	Returned to work in 6½ weeks; no complaints; function good	Some calcification of the coracoclavicular ligaments

The roentgenographic studies after operation revealed that all dislocations had been corrected. The five cases of calcification of the coracoclavicular ligaments noted at operation showed the ossification present in the last roentgenograms. In three cases no calcification of the trapezoid or conoid ligaments was observed on roentgenograms until four months after operation. Five cases showed some degenerative changes at the acromioclavicular joint, but in none of them did the patient have any complaints referable to this joint.

SUMMARY

A new operation is offered for recent or old acromioclavicular dislocations. By transference of the coracoacromial ligament to make a new superior acromioclavicular ligament, the dislocation is corrected and full motion at the acromioclavicular joint is maintained.

ABSTRACT OF DISCUSSION

DR. ANDREW SCHILDHAUS, Brooklyn: One of the reasons for the 20% failures in conservative management of complete dislocations is the inability to reduce accurately the posterior and superior displacement of the clavicle because of interposed soft tissue. Dr. Neviaser's procedure allows for anatomical reduction. The end results of his cases, at the end of two and five years, should be reported.

DR. JULIAN JACOBS, Charlotte, N. C.: The procedures which I have used in this injury have been either the use of a Velpeau bandage in the acute cases in the young and middle-aged or resection of the clavicle for pain or cosmetic reasons. The operation described will be given a trial.

DR. A. W. SPITTLER, Washington, D. C.: In regard to the West Point cadet, the problem is to reestablish his physical fitness so that he can meet the exacting requirements of an army officer. Repair of the acromioclavicular joint following injury is essential. I have had occasion to use the procedure and will continue to do so until such time as I find it to be unsatisfactory.

DR. JULIUS S. NEVIASER, Washington, D. C.: I want to thank the discussers for their criticism and comment. This procedure was originally devised after the use of a Kirschner wire in two cases. On removal of the wire the dislocation promptly recurred. It was evident from these results that in addition to the temporary fixation of a wire a permanent strut between the two bones was necessary. The procedure described is relatively simple and is performed with the patient in the sitting position.

Various authors have conclusively indicated that one may have an acromioclavicular dislocation without tearing the coracoclavicular ligaments. That is one of the reasons a new superior acromioclavicular ligament was made. There is another reason for transferring the coracoid attachment of the coracoacromial ligament to the clavicle. The distance between the acromion and the clavicle is less than the span between the clavicle and the coracoid process; thus we diminish the possibility of stretching the newly constructed bridge in addition to attaining a much greater mechanical advantage by this type of strut.

The complications of this operative procedure in our hands to date have been nil. The possibility of a latent symptomatic arthritis of this articulation is more theoretical than real and should not be used as a deterrent against the procedure. In fact, many instances have been reported of degenerative changes in this joint even in the nonoperative cases. If the pin should come loose before the five-week postoperative period has elapsed, the operative result should be unimpaired, as evidenced by a case in our series in which this occurred at the end of three weeks. As regards infection, the usual precautions and care practiced in all surgery should forestall this complication.

FEMORAL HERNIA

Operative Cases at the Johns Hopkins Hospital During a Twenty-One-Year Period

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BALTIMORE

FEMORAL hernia appears to be a rarer condition than most of us think. During the 21-year period from October, 1925, through December, 1946, there was a total of 139 patients with femoral hernia operated on in the Johns Hopkins Hospital. During the same period, there were 316,525 patients admitted to the hospital, exclusive of newborn babes. This meant 1 operation for femoral hernia for every 2,277 admissions. The cases in which a diagnosis of femoral hernia was made but no operation performed (relatively few) are not considered in this paper. McClure and Fallis[1] report 90 operations performed at the Henry Ford Hospital, Detroit, in a 20-year period during which there were 241,037 admissions. This means 1 femoral hernia operation for every 2,678 admissions—fewer proportionately than at the Johns Hopkins Hospital. This figure may be explained by the fact that the hospital census at the Johns Hopkins Hospital probably represents a truer cross section of the population than that at the Henry Ford Hospital because of the fact that at the latter hospital there is a large percentage of industrial patients, with a greater proportion of males than that in the general population. It is well known that femoral hernia occurs more frequently in the female than in the male.

INCIDENCE

Race Incidence.—Table 1 gives the general statistical data with regard to the cases reported here. One hundred seventeen patients were white and 22 Negro. As about one-third of the hospital population is Negro and two-thirds white, these figures seem to indicate that the incidence of femoral hernia is greater in the white race than in the Negro race. The figures may not necessarily mean that, however, because it may be that Negroes with femoral hernias do not present themselves for operation as often as do whites.

Sex Incidence.—Of the total number of patients, 46 (33%) were males and 93 (67%) were females. This ratio, I believe, conforms more or less to the general run. In McClure and Fallis' series, however, the proportion was 40% females and 60% males. They explained this by the fact that the bulk of their hernia practice was industrial in character, with a consequent greater proportion of males

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1. McClure, R. D., and Fallis, L. S.: Femoral Hernia: Report of 90 Operations, Ann. Surg. **109**:987-1000 (June) 1939.

than that which exists in groups of patients drawn from the nonindustrial elements of the population. In a series of 475 cases reported by Fergusson [2] the male-female incidence was 1:2.25.

Age Incidence.—Table 2 shows the age distribution and indicates that the greatest number of patients came to operation in the fourth, fifth, sixth, and seventh decades of life, the greatest number of operations being performed in the fifth decade. This means that 84% of the patients were between the ages of 30 and 70. (In McClure and Fallis' series, 76.7% were between the ages of 30 and 60.) The youngest patient was a 3-year-old Negro boy with an uncomplicated hernia, and the oldest was an 89-year-old woman with an incarcerated hernia. Unlike inguinal hernia, femoral hernia seldom occurs before puberty, and in this series there are only three patients less than 15 years of age.

TABLE 1.—*General Statistical Data on Series of Patients with Femoral Hernia*

	Total No. of Cases	White	Negro	Total Bilateral	Total Associated with Inguinal Hernia	Total Sliding (Bladder)	Total Recurrent	Total Incarcerated	Total Infected	Total Strangulated
Males	46	39	7	3	6	2	3	2	0	12
Females	93	78	15	2	2	1	2	12	1	25
Total	139	117	22	5	8	3	5	14	1	37

TABLE 2.—*Age Groups*

	1st Decade	2d Decade	3d Decade	4th Decade	5th Decade	6th Decade	7th Decade	8th Decade	9th Decade
Male	3	3	0	9	11	10	8	2	0
Female	0	1	5	14	29	18	18	5	2
Total	3	4	5	23	40	28	26	7	2

The age incidence reported by other authors corresponds roughly to that reported here. In Fergusson's series [2] the maximum incidence in women was between the ages of 25 and 50, while in men the greater number of cases occurred between 35 and 55. All authors agree that the condition is rare in children. Kazmann and Barnett [3] recently reported a case involving a boy of 5 years, and reviewed the literature, showing that the condition is indeed rare in children less than 6 years of age. As stated above, our youngest patient was a boy of 3 years. Jarboe and Pratt [4] reported a case involving a 5-month-old girl, in which the contents of the sac was strangulated ectopic endometrial tissue in an organized hematoma.

2. Fergusson, J. D.: A Statistical Investigation into the Results of Surgical Treatment of Femoral Hernia, St. Thomas's Hosp. Rep. **2**:209-219, 1937.

3. Kazmann, H. A., and Barnett, L. A.: Femoral Hernia: Report of 2 Unusual Cases, J. A. M. A. **143**:1335-1336 (Aug. 12) 1950.

4. Jarboe, J. P., and Pratt, J. H.: Strangulated Femoral Hernia: Relationship of Contents of Hernia Sac to Clinical Manifestations and Progress, Am. J. Surg. **77**:172-180 (Feb.) 1949.

TYPE OF HERNIA

Association with Inguinal Hernia.—In only five cases were the hernias bilateral. In eight patients there were associated inguinal hernias. Of these, two men each had an indirect inguinal hernia on the same side as the femoral hernia. One woman had an indirect inguinal hernia on the opposite side, and one had a direct hernia on the same side. One man had a direct hernia on the opposite side, and one had bilateral inguinal hernias (type not mentioned). Two men each had an indirect recurrent hernia on the same side.

Thus, it will be seen that in this series femoral hernia was associated with inguinal hernia in 5.8% of the cases. Many writers on the subject have remarked on the relationship of femoral hernia to inguinal hernia. In Fergusson's [2] series of 475 patients, 52 (11%) suffered from both femoral and inguinal hernias. In only two instances were both hernias present prior to the primary operation. Of the remaining 50 cases, in 27 femoral hernias appeared after an operation for inguinal hernia and in 23 inguinal hernias appeared after an operation for femoral hernia. In the 27 cases in which femoral hernia appeared after operation for inguinal hernia, 22 (76%) appeared on the side of the primary operation. In the 23 cases in which inguinal hernia appeared after operation for femoral hernia, 15 (65%) appeared on the side of the primary operation. In the series of McClure and Fallis,[1] 22.3% had been operated on previously for inguinal hernia on the side on which the femoral hernia appeared. They suggested that some of these patients were probably subjected to two operations because of a diagnostic error. They believed, however, that more than a casual relationship exists between femoral and inguinal hernias and that this relationship tends to support the congenital theory of the formation of femoral hernia.

Sliding Hernias.—There were three cases of sliding hernia, and in each case the bladder was the viscus involved. Sliding femoral hernia of the bladder is a fairly common occurrence. I have, however, been unable to find any account in the literature of a case of sliding femoral hernia in which any viscus other than the bladder formed a part of the wall of the hernia sac. I operated on a patient of my own about 10 years ago, an elderly woman, who had a sliding femoral hernia of the sigmoid. I expect to report this case in detail soon.

Recurrent Hernias.—There was a total of only five recurrent hernias, an incidence which would bear out the general impression that recurrent hernia is not as common in femoral as in inguinal hernia. The five patients had been operated on elsewhere previously. No attempt was made to follow up the patients in this series to determine the number of postoperative recurrences because of the great difficulty in tracing dispensary patients.

Some of the early reports on recurrence rates following the operation for femoral hernia led one to believe that the condition was easy to cure. At the time Bassini [5] first reported his operation for femoral hernia he had operated on 54 patients, with no recurrences in the 41 patients traced from one to nine years later. Ochsner [6] in 1906 reported on 56 patients, and in the 30 patients whom he had

5. Bassini, E.: Neue Operations-Methode zur Radicalbehandlung der Schenkelhernie, Arch. klin. Chir. **47**:1-25, 1894.

6. Ochsner, A. J.: Femoral Herniotomy, J. A. M. A. **47**:751-754 (Sept. 8) 1906.

been able to trace there were no recurrences. He did simply a high ligation of the sac, removal of the extraperitoneal fat from the femoral ring, and closure of the skin—the simplest of all operations. More recent reports have not been so good. In Fergusson's series [8] there were 9% recurrences. The recurrence rate after operation by the femoral route was 7.8%, and that after operation by the inguinal route was 9.1%. Butters [7] reported 120 operative cases. There were no recurrences among the 54 male patients but 4 recurrences among the 66 females. He obtained the most satisfactory results from the low operation. Ferguson [8] reported 4 recurrences in 16 femoral hernia operations (25%). Wakeley,[9] in reporting 610 cases from the Royal Navy, gave an operative recurrence rate for the low operation of less than 2%, for the high operation of nearly 9%, and for recurrent femoral hernias of over 60%. Dean,[10] with a series of 222 cases, gave the recurrence rate in uncomplicated femoral hernias as 12% and in strangulated femoral hernias as 23%. McClure and Fallis [1] reported a recurrence rate of 9.7% when the femoral route was used and 7.4% after operation by the inguinal route. Birt [11] stated that the recurrence rate for operations for femoral hernia varied from 5 to about 10% in various reported series of cases.

TABLE 3.—*Statistical Data on Cases of Incarcerated and Strangulated Femoral Hernia*

	Incarcerated		Strangulated				
	Part Involved		Part Involved				
	Omentum	Ileum	Omentum	Ileum	Appendix	Resection of Bowel	Richter's Hernia
Male	2	0	1	11	0	2	1
Female	11	1	2	22	1	7	4
Total	13	1	3	33	1	9	5

Contents of Sac.—In two cases (both of females) the sac contained the appendix. In one man the sac contained the sigmoid. In all other cases the sac either was empty or contained omentum or ileum.

Incarceration.—There were 14 cases (10%) of incarcerated hernia (see Table 3). In all these cases the omentum was the part incarcerated, except for one in which the ileum was incarcerated. In the latter case infection was also present, and at operation the ileum was injured and had to be resected.

Strangulation.—There were 37 (26.6%) cases of strangulated hernia (see Table 3), and of these the ileum was the strangulated part in 33 instances. There were three cases of strangulated omentum and one of strangulated appendix. Of the 33 cases of strangulated ileum, 8 required resection. (One of the nine cases with resection shown in the table was that of infected, incarcerated hernia, men-

7. Butters, A. G.: A Review of Femoral Hernias with Special Reference to Recurrence Rate of Low Operation, Brit. M. J. **2**:743-745 (Oct. 23) 1948.

8. Ferguson, D. J.: Recurrence Following Inguinal and Femoral Hernia Operations: 3 to 7½ Years Follow-Up, Minnesota Med. **32**:697-701 (July) 1949.

9. Wakeley, C. P. G.: Treatment of Certain Types of External Herniæ (Hunterian Lecture), Lancet **1**:822-826 (May 4) 1940.

10. Dean, G. O.: Strangulated Femoral Hernia, Arch. Surg. **44**:933-942 (May) 1942.

11. Birt, A. B.: Some Views on Femoral Hernia and Its Treatment, Practitioner **159**:362-368 (Nov.) 1947.

tioned in the preceding paragraph, in which the ileum was injured at the time of operation.) Of the eight patients with strangulated hernia requiring resection, three died (see Table 4).

Thus, it will be seen that of the total number of cases (139), 36.6% were either incarcerated or strangulated—an incidence very much higher than that found in any series of cases of inguinal hernia. The reason for this, of course, is the rigid environs of the femoral canal, which predispose to the wedging of the contents of the hernia sac tightly into the neck of the sac, causing incarceration or strangulation.

Richter's Hernias.—There were five cases of Richter's hernia, all strangulated. These are included in the cases of strangulated ileum (Table 3). The femoral canal, being narrow and its environs rigid, lends itself peculiarly to the development of Richter's hernia.

MORTALITY RATE

There were five deaths in the series (Table 4), a mortality rate of 3.6%. This is much higher than the mortality rate in operations for inguinal hernia. The reason for this, of course, is the much higher incidence of strangulation in femoral

TABLE 4.—*Deaths*

	No. with Resection of Strangulated Bowel	No. with Strangulated Bowel—Ileostomy	No. with Pneumonia
Male	1	0	1
Female	2	1	0
Total	3	1	1

hernia than in inguinal hernia. Three of these patients who died had had resection of strangulated bowel. One patient, an elderly woman, was in extremis because of strangulated bowel and, owing to her condition, a resection could not be done, but only an ileostomy. The fifth patient, an elderly man, died of pneumonia.

The over-all mortality rate (3.6%) in this series was low, considering the high incidence of strangulation and incarceration. The mortality rate for the strangulated cases was 10.8%. Birt [11] stated that the mortality rate for strangulated hernias of all types is about 5%. Dennis and Varco,[12] however, in 1947 stated that the published mortality rates for strangulated femoral hernia were high. They found only one report in the literature which mentioned a mortality rate as low as 25%. A couple of years later Jarboe and Pratt [4] reported 104 cases of strangulated femoral hernia from the Mayo Clinic, with an over-all mortality rate of 23.1%. In those cases in which the contents of the hernia sac was small intestine, the mortality rate was 36%. In those cases in which the hernia sac contained viscera other than the small intestine, the mortality rate was 2.5%. In the series of McClure and Fallis,[1] the mortality rate in the strangulated group was 15.2%, while the over-all mortality rate for the series was 4.4%. Butters [7] reported a

12. Dennis, C., and Varco, R. L.: Femoral Hernia with Gangrenous Bowel, Surgery **22**:312-323 (Aug.) 1947.

mortality rate of 13.3% in his 45 cases of strangulated hernia. The mortality rate in his nonstrangulated cases (133) was zero. In Fergusson's[2] large series (475 cases), the mortality rate for strangulated hernia was 3.5% and for reducible hernia 0.4%. Watson[13] noted mortality rates of 18% when operation for strangulated hernia was early and of 50% when the operation was delayed. Dean[10] found the mortality rate in his cases of strangulated femoral hernia to be 32%, with a recurrence rate of 23% (only 45% were cured by the operative procedure), and concluded that if a patient with a femoral hernia wants to be offered better than a 70% chance of remaining alive and better than a 50% chance of being cured, operation should be performed early.

One possible reason for high mortality rate in strangulated femoral hernia is that often the condition is unrecognized by the general practitioner who first sees the patient. A great many patients are admitted to hospitals vomiting and with obstruction without the femoral region having been examined. Generally such examination has not been made because the hernia is small and the mass has not been detected by the patient herself. This is especially apt to be true in elderly fat women. Often in strangulated Richter's hernias no mass can be palpated.

METHOD OF REPAIR

The various types of surgical approach used were as follows:

	No. of Cases	% of Cases
Femoral	67	46.5
Inguinal	49	34.0
Combined	24	16.7
Abdominal	4	2.8
Total	144 (5 bilateral)	

The femoral approach was far more commonly used in the earlier cases, and the inguinal approach was predominant in the later cases. Operators using the femoral approach employed three different types of incisions: (1) a vertical incision over the femoral hernia; (2) an oblique incision parallel to and below Poupart's ligament (ligamentum inguinale), and (3) a hockey-stick incision starting parallel to Poupart's ligament and curving downward over the femoral hernia. Those using the inguinal approach employed the usual oblique inguinal incision above Poupart's ligament. When a combined femoral and inguinal approach was used, it was often started with one of the three types of incisions used in the femoral approach and was converted into an inguinal approach by modifying the original incision or by making a new incision. As a rule, the reason for changing from the femoral to the inguinal approach was the encountering of strangulated bowel which could not be dealt with properly from below. Often the combined approach was employed through the usual inguinal incision, over or just above Poupart's ligament, dissecting back the subcutaneous tissue below the ligament, exposing the sac in the femoral region first, and then opening the peritoneal cavity by splitting the aponeurosis of the external oblique muscle and going through the transversalis fascia.

In making the repair from below, the usual operation employing the pectineus fascia, the falciform process, and Poupart's ligament to close the femoral opening, with either a purse-string or mattress sutures, was performed. This operation was

13. Watson, L. F.: Hernia, Ed. 3, St. Louis, C. V. Mosby Company, 1948, p. 330.

originally devised by Bassini [9] and has given satisfactory results over a long period of years. (A somewhat similar operation had been described by Cushing [14] six years earlier.) The operation is easier than that performed through the inguinal approach and is suitable for repair of simple hernias in which the sac either is empty or contains reducible contents. The operation has the drawback of closing only the outlet of the femoral canal and of not blocking off the entire canal, as is possible when the inguinal operation is done.

The inguinal approach was first used by Annandale [15] in 1876. Annandale, however, depended for a cure upon plugging the femoral canal by suturing the sac into it. He used neither Cooper's nor Poupart's ligament in the repair. He inveighed against the so-called radical operation for hernia. In the present series of cases, when the inguinal approach was used either the inguinal ligament or the conjoined tendon was sutured to Cooper's ligament. The inguinal ligament was first sutured to Cooper's ligament by Ruggi [16] in 1892, and the procedure was popularized in this country by Moschcowitz.[17] Moschcowitz added to the Ruggi operation by doing an inguinal hernioplasty in order to prevent an inguinal recurrence. The conjoined tendon was first sutured to Cooper's ligament in hernia repair by Lotheissen [18] in 1898. The Lotheissen procedure is much the better of the two. McVay and Anson [19] have pointed out that in suturing the conjoined tendon to Cooper's ligament the fascial planes are not transposed as is the case when Cooper's ligament is sutured to Poupart's ligament, the latter lying in a fascial plane superior to that in which Cooper's ligament lies. Besides, in suturing Cooper's ligament to Poupart's ligament, one completely unyielding and one relatively unyielding structure are sutured together. In suturing the conjoined tendon to Cooper's ligament, the femoral canal is completely blocked off, and the operation has both anatomical and technical advantages not enjoyed by the operations of Ruggi and Moschcowitz. The inguinal approach has obvious advantages over the femoral in dealing with strangulated or incarcerated hernia.

The abdominal approach deserves special comment, and in this series was used only by the gynecologists. When the pelvis was explored for some other condition and a femoral hernia was found, the fundus of the sac was grasped with a Kelly clamp and inverted into the peritoneal cavity. The sac was then excised and the femoral ring closed with a purse-string suture. So far as I have been able to

14. Cushing, H. W.: An Improved Method for the Radical Cure of Femoral Hernia, Boston M. & S. J. **119**:546-548 (Dec. 6) 1888.

15. Annandale, T.: Case in Which a Reducible Oblique and Direct Inguinal and Femoral Hernia Existed on the Same Side, and Were Successfully Treated by Operation, Edinburgh M. J. **21**:1087-1091 (June) 1876.

16. Ruggi, G.: Metodo operativo nuovo per la cura radicale dell' ernia crurale, Bull. sc. med. Bologna, Ser. 7, No. 3, 1892, pp. 223-228.

17. Moschcowitz, A. V.: New Operation for the Radical Cure of Femoral Hernia, J. A. M. A. **48**:899 (March 9) 1907; Femoral Hernia: A New Operation for the Radical Cure, New York J. Med. **7**:396-400 (Oct.) 1907.

18. Lotheissen, G.: Zur Radikaloperation der Schenkelhernien, Zentralbl. Chir. **25**:548-550 (May 28) 1898.

19. McVay, C. B., and Anson, B. J.: A Fundamental Error in Current Methods of Inguinal Herniorrhaphy, Surg., Gynec. & Obst. **74**:746-750 (March) 1942.

ascertain, the abdominal approach was first used by Tait [20] in 1883. While operating for an ovarian tumor, he noticed the presence of a femoral hernia in which intestine was adherent. He released the adhesions and closed the ring with a silk suture. He made no mention of removing the sac. At the Johns Hopkins Hospital, Kelly [21] was the first to use the abdominal operation as described at the beginning of this paragraph. I do not believe that he was aware of Tait's operation when he first used the abdominal approach, but on operating for some other pelvic condition and encountering a femoral hernia, his ingenuity led him to devise the type of closure described. He used it frequently with excellent results, but his cases were too early to be included in this paper. The other gynecologists on the staff have also used it frequently in the many hospitals in which they work and with excellent results. In the early days of the hospital, Kelly sometimes put a glass marble in the femoral canal and closed it over with peritoneum. He nearly always had a number of visitors in his clinic and often in operating on the same patient subsequently for another condition, he would get great fun from pointing to the varicolored marble showing through the peritoneum and listening to the speculations of the visitors when he asked them what they thought the condition was.[22]

PERSONAL CASES

During the three-year period since this study was begun, I have operated on seven patients with femoral hernia not included among the 139 patients of this series. Their hernias were in the following categories:

	No. of Patients	Results
Primary	1	Well after 18 mo.
Recurrent	2	Well after 3 yr. and 19 mo., respectively
Twice-recurrent	2	Well after 11 mo. and 10 mo., respectively
Thrice-recurrent	2	One well after 11 mo.; one recurred

The fact that six of the seven patients had recurrent hernias, and that four of them had been operated on more than once before, is an indication that the recurrence rate in femoral hernia may be about the same as that in inguinal hernia. Of the seven patients operated on, one has had a recurrence. This patient was a very fat woman with a chronic cough who had been operated on three times before; in addition to the femoral hernia, she had a twice-recurrent ventral hernia, an umbilical hernia, and a Spigelian hernia. All these defects were repaired at the same operation, and the thrice-recurrent femoral hernia is the only one of the defects that has recurred (now four times recurrent). This case is a prime example of some of the difficulties that surgeons have to contend with beyond the art which they practice. The patient would do nothing to reduce her weight and refused to stop smoking, which was the principal cause of her cough—a pure and simple case of disgusting self-indulgence.

20. Tait, L.: On the Radical Cure of Exomphalos, Brit. M. J. **2**:1118-1119 (Dec. 8) 1883.

21. Kelly, H. A.: Femoral Hernia, in Operative Gynecology, New York, D. Appleton & Company, 1898, Vol. 2, pp. 490-491; Femoral Hernia, ibid., Ed. 2, 1906, Vol. 2, pp. 604-607.

22. Cullen, T. S.: Personal communication to the author, March 20, 1951. Hunner, G. L.: Personal communication to the author, Feb. 23, 1951. Neill, W., Jr.: Personal communication to the author, March 20, 1951.

The first of these seven patients (one with a recurrent hernia) was operated on in April, 1948, and the repair was accomplished by suturing Poupart's ligament to Cooper's ligament, using the LaRoque[23] approach. Repair in five patients, including the one with thrice-recurrent hernia, which recurred again after my operation, was accomplished with suture of the conjoined tendon to Cooper's ligament. The patient with primary hernia was the only one in whom the femoral approach was used. This patient was an elderly woman with severe asthma and a cardiac condition; it was felt, therefore, that the simpler the operation the better. She has been well for 18 months.

SUMMARY

Statistical data are furnished with regard to 139 patients with femoral hernia operated on at the Johns Hopkins Hospital, Baltimore, during a 21-year period. The small number of patients operated on in a large hospital during such an extended period indicates the relative rarity of this type of hernia. Evidence is presented that the recurrence rate may be higher than is generally supposed. The various methods of repair are discussed.

23. LaRoque, G. P.: The Permanent Cure of Inguinal and Femoral Hernia: A Modification of the Standard Operative Procedures, Surg., Gynec. & Obst. **29**:507-510 (Nov.) 1919.

SURGICAL TREATMENT OF ARTERIOSCLEROTIC ANEURYSMS OF THE ABDOMINAL AORTA

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WITH THE general increase in life expectancy, the problem of caring for arteriosclerotic aneurysms arises in many clinics. Of the aortic aneurysms, the thoracic ones can be recognized earlier, and since they are often syphilitic the tissue response to various attempts at obliteration is more intense. On the other hand, the abdominal aneurysms of the aorta may run a long, asymptomatic course [1] and are far oftener arteriosclerotic [2]; in them the degenerated wall with its poor blood supply offers added difficulties.

While the syphilitic, arteriosclerotic, and mycotic types of aneurysm can be held apart with fair certainty (recognizing, of course, combinations of several varieties in the same vessel), little attention has been paid, at least in this country, to the cystic medial necrosis of Erdheim,[3] a lesion which consists of patches of muscle necrosis or cysts filled with mucoid material. This lesion may be found even far away from the aneurysmal sac. The exact incidence of these different types of abdominal aortic aneurysms varies in older and more recent statistics. Generally speaking, more recent data indicated an overwhelming preponderance of arteriosclerotic against the syphilitic variety in the abdomen. Thus Estes,[2] in reviewing 102 abdominal aortic aneurysms from the files of the Mayo Clinic, found 97 aneurysms due to arteriosclerosis, 1 due to syphilis, 3 due to arteriosclerosis and syphilis, and 1 due to trauma. It should be noted, however, that for 35 patients there was no record of objective evidence of any etiologic factor except that they were over 50 years of age and the lesions were thus regarded as being arteriosclerotic. It would also seem that most abdominal arteriosclerotic aneurysms are fusiform and occur below the renal arteries; the involvement of the inferior mesen-

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1. Blakemore, A.: The Clinical Behavior of Arteriosclerotic Aneurysms of the Abdominal Aorta: A Rational Surgical Therapy, Ann. Surg. **126**:195, 1947.

2. Estes, E. J., Jr.: Abdominal Aortic Aneurysm: A Study of 102 Cases, Circulation **2**:258, 1950.

3. Erdheim, J.: Mediconecrosis Aortae Idiopathica Cystica, Arch. path. Anat. **276**:187, 1930.

teric artery in the aneurysmal sac is not an important consideration in attempts at obliteration.[4]

METHODS OF DIAGNOSIS

Abdominal aneurysms grow insidiously, and many of them have first been discovered on palpation of the abdomen or on laparotomy done for some other cause. In the excellent survey made by Estes,[2] 30.4% of 102 patients had no symptoms referable to the aneurysm. The symptoms and signs in his series are reproduced in Tables 1 and 2. Blakemore [1] has called attention to the fact that arteriosclerotic abdominal aneurysms seldom, if ever, cause vertebral erosion. Severe back pain in one of our cases (Case 3) occurred in a mixed syphilitic-arteriosclerotic variety.

TABLE 1.—*Symptoms in Abdominal Aortic Aneurysm* [2]

	Patients	Per Cent of 102 Patients
Abdominal pain	38	37.3
Abdominal mass	26	25.5
Abdominal throbbing	17	16.7
Backache	14	13.7
Gastrointestinal symptoms	10	9.8
Shock	8	7.8
Leg pain	3	2.9
None	31	30.4

TABLE 2.—*Physical Signs in Abdominal Aortic Aneurysm* [2]

	Patients	Per Cent of 102 Patients
Expansile, pulsatile abdominal mass	90	88.3
Thrill or bruit	29	24.4
Nonpulsatile abdominal mass	3	2.9
Other aneurysm	2*	2.0
Anemia	2	2.0
Abdominal rigidity	1	1.0
None	7	6.9

* One patient had a popliteal aneurysm and 1 patient had bilateral fusiform dilatation of the femoral arteries.

Renal colic, perinephritic abscess, hydronephrosis, or uremia may be simulated by an abdominal aneurysm, and urologists may be the first ones to encounter it.[5] Neurologists may be faced with manifestations of spinal-cord ischemia in the dissecting variety,[6] but we have encountered three cases of fusiform abdominal aneurysm in which the first symptoms were those of spinal cord ischemia, one of them exhibiting a neurotrophic hip joint in the orthopedic service and manifesting itself by rupture. The scout roentgenogram of the abdomen provides one of the most helpful, simple methods of visualizing the aneurysmal sac by means of scattered,

4. Archibald, E.: Operative Treatment of Cancer of the Rectum, J. A. M. A. **50**:573 (Feb. 22) 1908.

5. Uhle, C. A.: The Significance of Aneurysm of the Abdominal Aorta Masquerading as Primary Urologic Disease, J. Urol. **45**:13, 1941.

6. Moersch, F. P., and Sayre, G. P.: Neurologic Manifestations Associated with Dissecting Aortic Aneurysm, J. A. M. A. **144**:1141 (Dec. 2) 1950.

calcified plaques, curvilinear, linear or laminated calcification, or simply the presence of a large oval or spheroid soft-tissue mass. Even so, 14% of Estes' series did not show any roentgenologic evidence of abdominal aneurysm. Displacement of the esophagus, duodenum, or ureter may be of some diagnostic help. Aortographic studies have recently been performed on our service, and certainly this method, now carried out with the patient under local anesthesia with 20 cc. of 75% sodium iodomethamate (neo-iopax®) [7] gives a perfect image of the size of the neck, of the shape of the aneurysm, and of the width of the laminated clot and helps in the planning of surgical treatment. Blakemore,[8] for many years has used this method to ascertain the effect of surgical therapy.

ASSOCIATED VASCULAR DAMAGE

Every one of our patients suffering from arteriosclerotic aneurysm subjected to a cardiovascular study exhibited generalized vascular involvement. From the standpoint of surgical indication, the extent of myocardial damage, the renal reserve, the involvement of the thoracic aorta, and the patency and sclerosis of the femoral vessels and its branches must be considered. Hypertension is frequent and, when absent in spite of heart enlargement may represent myocardial failure in a previously hypertensive patient. Cerebral vascular sclerosis with its concomitant mental deterioration may render any surgical attempt futile.

INDICATIONS FOR SURGICAL TREATMENT

The instructive life expectancy curve of Estes [2] indicates that the survival rate of patients suffering from abdominal aneurysms was much lower than that of the normal population at 65 years. He showed that 63.3% of the patients died from a rupture of the aneurysm and 36.7% died from other sources. This observation is not surprising when one realizes the amount of associated vascular damage and urges moderation when a surgical attack is planned for a patient who may soon die from a vascular accident in another part of the body.

Our indications for the surgical treatment of aneurysm were influenced by the following considerations: 1. Survival rates for asymptomatic aneurysms are no higher, and hence the absence of symptoms should not delay operation. 2. Severe hypertension is not a contraindication although the risk of erosion of the vessel wall and aneurysm formation proximal to the constriction is theoretically increased. 3. There is really no age limit, although patients in their fifties certainly can tolerate more extensive procedures than those in their seventies. 4. Cerebrovascular accidents, and coronary occlusions are not contraindications, provided four to six months have elapsed since the acute episode and no important residual damage has resulted. 5. Myocardial failure and early renal failure are contraindications to surgery. Our only operative death was from uremia; the proximity of the renal vessels to surgical manipulation and especially the inflammatory reaction caused by the tissue irritant may cause death.

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7. Deterling, R.: Paper read before the Meeting of the Society for Vascular Surgery, Atlantic City, N. J., June, 1951.

8. Blakemore, A.: Progressive Constrictive Occlusion of the Abdominal Aorta with Wiring and Electrothermic Coagulation, Ann. Surg. **133**:447, 1951.

ANALYSIS OF PREVIOUS SURGICAL METHODS

Several principles have been employed in the past to stabilize, inactivate, obliterate, or cure an abdominal aneurysm. These attempts fall into the following groups:

1. Ligation of the abdominal aorta proximal to the aneurysm. This has been reported since 1817 in a total of 37 cases. The following conclusions are justified on the basis of past experience: A one-stage complete or partial occlusion of the aorta, whether accomplished with silk, cotton tape, silver, aluminum or tantalum bands, is hazardous [9] because of the atrophy, necrosis, and erosive hemorrhage under the band, aside from the ischemic effects on the spinal cord and the extremities. In patients in whom a slow leak with retroperitoneal hemorrhage interferes with collateral circulation to one of the extremities, gangrene may develop, necessitating high amputation.[10] Even three-stage occlusions of the aorta with rubber bands followed by division, so successful in the experimental animal,[11] are not tolerated in the human being.[12]

Of the 37 ligations of the human abdominal aorta, 8 were reported as successful, the patients living more than six months, whereas 18 died in less than 24 hours. This does not mean, however, that partial ligation is to be entirely discarded as a useful surgical principle. Combined with other methods it serves an important purpose.[9d] Most important, Blakemore [8] was of the opinion that a decrease of the diameter of the aorta to less than 75% produces a nozzle effect, with an exaggeration of the rate of flow within the sac and added strain on its wall. He recommended an 80% constriction, the effect of which can be measured by his electrothermic method of heating 10 ft. (305 cm.) of wire to 80 C. by a certain number of amperes. Clinically, the decrease of pulsation in the oscillometer to one or one-half of a division at the thigh seems a useful guide; furthermore, the postoperative arteriogram should show a constriction down to the size of a cigarette.

2. Wiring of the aneurysmal sac. This method has a long history. Cold wire was inserted into the lumen of vessels to be obliterated by Moore [13] in 1864 and insulated wire heated by a galvanic current by Corradi [14] in 1879. Colt,[15] who reviewed his many years' experience with opening a miniature umbrella in the sac,

9. (*a*) Halsted, W. S.: The Partial Occlusion of Blood Vessels, Especially the Abdominal Aorta, Bull. Johns Hopkins Hosp. **16**:346, 1905. (*b*) Matas, R.: Occlusion of Large Surgical Arteries with Removable Metallic Bands to Test the Efficiency of the Collateral Circulation, J. A. M. A. **56**:233 (Jan. 28) 1911. (*c*) Reid, M. R.: Partial Occlusion of the Aorta with Silk Sutures and Complete Occlusion with Fascial Plugs: the Effect of Ligatures on Arterial Walls, J. Exper. Med. **40**:293, 1924. (*d*) Cooper, F. W., Jr.; Robertson, R. L.; Shea, P. C., Jr., and Dennis, E. W.: The Experimental Production of Gradual Occlusion of Large Arteries with Polythene and Tantalum, Surgery **25**:184, 1949.

10. Morton, J. J., and Scott, W. J. M.: Ligation of the Abdominal Aorta for Aneurysm, Ann. Surg. **119**:457, 1944.

11. Owens, J. C., and Hewett, J. F.: Successful Experimental Ligation and Division of the Thoracic Aorta, Ann. Surg. **115**:596, 1942.

12. Monahan, D. T., in discussion on Gage, I. M.: The Technical Simplicity of the Matas Endoaneurysmorrhaphy, Ann. Surg. **119**:468, 1944.

13. Moore, C. H., and Murchison, C.: On a New Method of Procuring the Consolidation of Fibrin in Certain Incurable Aneurisms, London, 1864, pp. 21.

14. Cited by Dean Lewis, in Practice of Surgery, J. B. Lippincott Co., Vol. 12, Chap. 5-E.

15. Colt, G. H.: Treatment of Aortic Aneurysm, M. Press. **194**:499 (May 26) 1937.

has given a fascinating story of his observations with this method. Most of these authors wired thoracic aneurysms, and their results were inconclusive or unpredictable. Blakemore [1] crystallized the point that a "method of wiring aneurysms to be efficient in the induction of mass (brimful) clotting must fulfill the following requirements: (1) it must afford an adequate and efficient clot-stimulating surface to the passing blood; and (2) it must furnish a means of measuring blood flow in the individual aneurysm as a guide to the amount of wire it is necessary to introduce to impede the blood to a rate of flow at which, in the presence of an adequate clot-stimulating surface, complete mass clotting of the aneurysm will take place."

Linton [16] has more recently produced evidence that the cold wire, if introduced in sufficient length, is capable of bringing about massive clotting without the necessity of measuring rapidity of blood flow in the sac and without heating the wire.

3. Endoaneurysmorrhaphy. Since this method has been so widely employed in the treatment of popliteal aneurysm, it is strange that only five cases are on

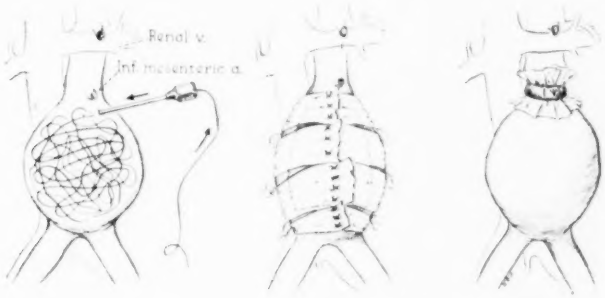

Fig. 1.—The three diagrams illustrate the principles of wiring, wrapping, and partial proximal compression in the treatment of abdominal aneurysms. The wiring can be done with a huge mass of cold wire or with wire heated with electric current. The wrapping has been done with cellophane, fascia lata, or cutis. The proximal constriction shown here is done with a cellophane collar above which rubber has been applied.

record in which it has been used on the abdominal aorta. Bigger's successful case [17] was that of a young man with an intact cardiovascular apparatus who suffered a traumatic aneurysm of the aorta. Since obliterative endoaneurysmorrhaphy demands a safe and complete closure of the proximal end of the sac, the problem of arterial erosion and aneurysm formation above the ligature still remains, as outlined above in cases of vascular sclerosis. Recently, Wylie and his associates restored the lumen of the sac and reinforced the wall with fascia lata.[18]

16. Linton, R. R.: Intrasaccular Wiring of Abdominal Arteriosclerotic Aneurysms by the "Pack" Method, Angiology, to be published.

17. Bigger, I. A.: The Treatment of Aneurysms of the Abdominal Aorta, Ann. Surg. **112**:879, 1940.

18. Wylie, E. J.; Kerr, E., and Davies, O.: Experimental and Clinical Experience with the Use of Fascia Lata Applied as a Graft About Major Arteries After Thromboendarteriectomy and Aneurysmorrhaphy, Surg., Gynec. & Obst. **93**:257, 1951.

4. Production of progressive fibrosis by tissue irritants. In dogs Page produced a thick perirenal fibrosis with cellophane.[19] Pearse [20] succeeded in developing a gradual complete occlusion of the aorta with cellophane; while no external compression was used, three dogs died of rupture of the aorta. Yeager and Cowley [21] isolated dicetylphosphate as the irritant factor in cellophane. Prior to their study there was great uncertainty as to the irritating effect obtained with this material. Evans and Zeit [22] studied a number of asymmetrical crystals generating piezometric electric currents and thus producing tissue fibrosis. Our own single observation with such material will be reported here. One of us (G. de T.) wrapped a snug cellophane collar around the neck of a fusiform abdominal aneurysm in 1943 and since that time has accumulated a small series of cases in which cellophane was used.[23] Our interest was originally aroused by the report of Harrison and Chandy,[24] who wrapped cellophane proximally and distally to subclavian aneurysms of two Arabs. One of these attempts was successful, the complete occlusion taking 19 months. Harper and Robinson [25] placed cellophane about a patent ductus arteriosus after its ligation in continuity with silk. The murmur recurred after operation but

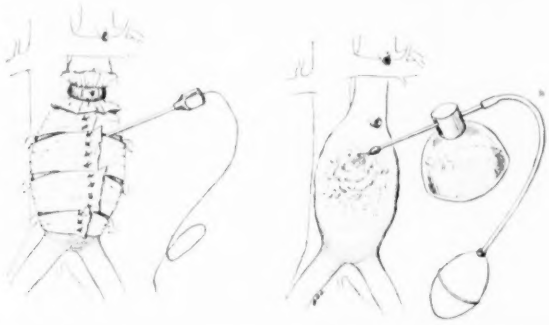

Fig. 2.—The diagram on the left illustrates the combination of the three methods depicted individually in Figure 1. On the right the aneurysmal wall is being sprayed with 2% solution of dicetylphosphate.[28]

again disappeared in two months. The final occlusion was attributed to cellophane. Poppe and Oliviera [26] attacked the thoracic aneurysms by wrapping them in cello-

19. Page, I. H.: The Production of Persistent Arterial Hypertension by Cellophane Perinephritis, J. A. M. A. **113**:2046 (Dec. 2) 1939.

20. Pearse, H. E.: Experimental Studies on the Gradual Occlusion of Large Arteries, Ann. Surg. **112**:923, 1940.

21. Yeager, G., and Cowley, R. A.: Studies on the Use of Polythene as a Fibrous Tissue Stimulant, Ann. Surg. **128**:509, 1948.

22. Evans, S. M., and Zeit, W.: Tissue Responses to Physical Forces: II. Response of Connective Tissue to Piezoelectrically Active Crystals, J. Lab. & Clin. Med. **34**:592, 1949.

23. de Takats, G., and Reynolds, J. T.: The Surgical Treatment of Aneurysms of the Abdominal Aorta, Surgery **21**:443, 1947.

24. Harrison, P. W., and Chandy, J.: A Subclavian Aneurysm Cured by Cellophane Fibrosis, Ann. Surg. **118**:478, 1943.

25. Harper, B. R., and Robinson, H. W.: Occlusion of Infected Patent Ductus Arteriosus with Cellophane, Am. J. Surg. **64**:294, 1944.

26. Poppe, J. K., and Oliviera, H. R.: Treatment of Syphilitic Aneurysms by Cellophane Wrapping, J. Thoracic Surg. **15**:486, 1946.

phane and reported encouraging results. They found that 1.5 ml. of Du Pont cellophane gave consistent reaction in animals and were first to point out the variability of response to different types of cellophane.

Difficulty has been encountered in sterilizing the polyethylene film impregnated with dicetylphosphate powder. Soaking the impregnated film in 1 : 1,000 aqueous benzalkonium chloride solution for 20 minutes removes less of the dicetylphosphate than other methods of sterilization.[27] Berman and his associates [28] used 0.9% dicetylphosphate in olive oil to produce fibrosis. Numerous other substances have been used to stimulate fibrous tissue formation, such as asbestos powder, talcum powder, quartz, or aluminum phosphate. Lowenberg [29] used a cutis graft to support the aneurysmal wall and produced fibrosis. Grindlay and Waugh [30] placed a thin sheet of polyvinyl sponge over the wall of four abdominal aneurysms with the expectation that fibrous tissue will grow into the sponge and strengthen the sac.

5. Combination of above-described methods. The idea that a partial ligature might be safer when it is placed over a cellophane collar was explored by Cooper

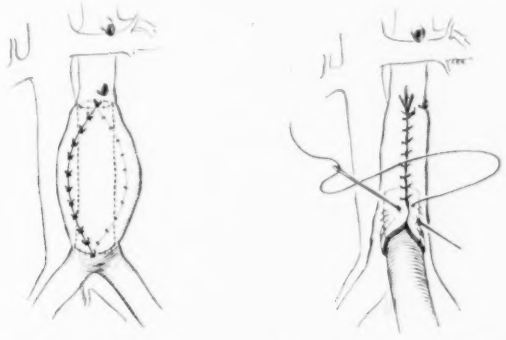

Fig. 3.—On the left the diagram illustrates the partial excision of the sac and the lumen of the aorta restored with vein-inlay graft.[31] On the right the aneurysmal sac has been completely excised and the lumen restored over a large rubber tube which is then removed before the last sutures are placed. This method would hardly apply to an arteriosclerotic aneurysm.

and his associates,[9d] who placed four layers of polythene on the aorta of dogs and then tightened a tantalum band 1-cm. wide around it. The use of the metallic band and polythene overcame the inherent disadvantages of either material alone. The mass of fibrous tissue acted to prevent erosion of the arterial wall or aneurysm formation. Blakemore [8] combined the cellophane collar with a graded constriction obtained by sling-shot rubber bands. As pointed out before, he insists on a constriction of not more than 80% and not less than 60%, preferably 75%, and accomplishes this by blood-flow measurements within the sac. He indicated the value

27. Questions and Answers, J. A. M. A. **146**:509 (June 2) 1951.

28. Berman, J. K.; Boyd, F. J., and Saint, W. K.: The Treatment of Thoracic and Abdominal Aneurysms of Syphilitic and Arteriosclerotic Origins, J. Indiana M. A. **42**:889, 1949.

29. Lowenberg, E. L.: Aneurysm of the Abdominal Aorta: Report of 2 Cases Treated by "Cutis Grafting," Angiology **1**:396, 1950.

30. Grindlay, J. H., and Waugh, J. M.: Plastic Sponge Which Acts as a Framework for Living Tissue: Experimental Studies and Preliminary Report of Use to Reinforce Abdominal Aneurysms, A. M. A. Arch. Surg. **63**:288 (Sept.) 1951.

of elastic resilience in delaying atrophy of the vessel below the band and pointed out that the softer rubber edges are everted with each pulse wave, thus assuming an hour-glass configuration when the bands are secured with two mattress silk sutures. Blakemore also combined the use of a ball of cold wire, placed as an impediment to blood flow in the neck of the aneurysm, with an electrothermic coagulation of the sac itself.

6. Vein-inlay graft. Recently, Freeman [31] presented an ingenious method of placing a homologous vein segment into the widely opened aneurysmal sac, stitching the vein to the proximal and distal segments of the aorta and allowing the clotted blood formed between the vein graft and the aneurysmal sac to produce an added support, with the lumen of the vein serving as the central channel. Collapse of this channel from external pressure is prevented by aspirating the perivenous, intrasaccular blood to a point at which the pressure in the new channel is higher than the pressure surrounding it. The immediate result in one case is gratifying.

OWN MATERIAL

We have reviewed briefly, and no doubt imperfectly, the literature available to us up to date and now wish to present our own observations which have accumulated slowly with different techniques and their combinations.

Early in our experience, between 1930 and 1940, one of us (G. de T.) wired 31 thoracic aneurysms, of which 28 were syphilitic and 3 arteriosclerotic.[32] Most of the material was referred to us from the outpatient clinic of the United States Public Health Service by the late Dr. Kempf, which source perhaps explains the preponderance of syphilitic aneurysms in comparatively young persons. The method used was essentially that of Corradi.[14] A shellacked spinal puncture needle was inserted percutaneously into the sac with the patient under local anesthesia. After premedication with morphine and 1/60 grain (0.001 gm.) of atropine, a No. 4 stainless steel wire was inserted by hand from a tight spool. This usually allowed the insertion of 10 to 15 ft. (305 to 457 cm.) of wire, seldom more. Next the cut end of the wire was connected with a galvanic current which was slowly raised to 60 ma. and back to 0, the whole procedure taking about 30 minutes.

In spite of this primitive method, inactivation of the aneurysm occurred in 14 of the 31 cases, or a little under 50%. By inactivation we mean that in 14 patients the pain was relieved, pulsation diminished, and threatening perforation through the anterior chest wall delayed by formation of a hard, palpable clot. The small saccular aneurysms did much better than the large, fusiform ones. The average duration of life after this procedure was two years, and in three cases a splitting of the sternum had to be done for threatening tracheobronchial obstruction. The remaining 17 patients derived no benefit from the procedure; insufficient wiring, huge fusiform, transverse, aortic lesions, and bronchial compression with atelectatic pneumonia were thought to be the causes of failure.

We mention this experience gained with early, insufficient methods on thoracic aneurysms only to explain our scepticism in using it for abdominal aneurysms, which are in less reactive, more aged, and more degenerated vessels and are wide-

31. Freeman, N. E.: Paper Presented at the June 1951 Meeting of the Society for Vascular Surgery, Atlantic City, N. J.

32. de Takats, G., and Lasner, J.: Unpublished data.

mouthed, fusiform aneurysms. Ten syphilitic abdominal aneurysms were wired at Johns Hopkins Hospital about that time, and only one case showed benefit.[33] For this reason one of us became interested in cellophane as a constricting agent, stimulated by the reports of Page, Pearse, and Harrison and Chandy.[24] Here again, we were unaware at first of the great importance of dicetylphosphate as the essential irritant and have certainly used nonirritant cellophane in at least one patient. The cellophane was used as a snugly fitting collar above the aneurysm, as a wrapping for the entire sac, or as an apron over the endangered soft area, where perforation was threatening. The case histories of three patients were given in detail in 1947.

A glance at Table 3 will show that the cellophane collar (with no or minimal constriction) or the cellophane wrap of the sac produced little effect in Cases 1, 2, and 3 except for temporary pain relief. The firm support of the sac in Case 5 with a

TABLE 3.—*Surgical Treatment of Abdominal Aneurysms*

Case	Age	Sex	Cause	Technique	Result	Follow Up
1	69	M	Hypertension *	Cellophane collar	Decrease in size	Refused second operation; died 14 mo. postoperatively
2	55	M	Hypertension	Cellophane collar and apron	Decrease in size; pain relief	Died suddenly 24 mo. postoperatively
3	57	M	Arteriosclerosis	Cellophane collar	Pain disappeared; pain in back	Died 8 mo. postoperatively of coronary occlusion; lumen of aorta narrow †
4	58	M	Arteriosclerosis	Cellophane wrap and talcum	Asymptomatic; works full time	3 yr.
5	54	M	Arteriosclerosis, cardiac failure	Cutis graft around sac	Pain relief; no shrinkage	1 yr.; frequent decompensation
6	54	M	Syphilis	Wiring twice; cordotomy	Temporary pain relief after each wiring	Died after high cordotomy
7	..	M	Hypertension	Cellophane wrap and quartz dust	.....	Died of uremia 7th postoperative day
8	60	M	Arteriosclerosis	Cellophane wrap and talcum powder	.....	1½ yr.
9	58	M	Hypertension, arteriosclerosis	Cellophane wrap	Asymptomatic for 4 yr.	Died of coronary occlusion 4 yr. postoperatively
10	58	M	Arteriosclerosis and hypertension; acute rupture	Cellophane collar and wiring	.....	Died 2 wk. after operation of recurrent hemorrhage †

* Denotes arteriosclerotic aneurysms with hypertension.
† Complete autopsy report available.

cutis graft resulted in pain relief in spite of no detectable shrinkage of the sac. Since there is no vertebral erosion in the arteriosclerotic variety, such pain may be due to pulsatile distention, which is dampened by a firm support. Whether this cutis graft can be regarded as a fibrosing agent cannot be stated at present, but it is a tough "retreading" material, as Lowenberg [29] expressed it.[34]

We feel, then, that the cellophane collar or apron, as one of us, along with Reynolds, described it, has not kept its promise, all the more because of our initial uncertainty about the type of cellophane which produces fibrosis. Improvement here came from two sources. One was the addition of irritant talcum powder (made in Cases 4 and 8, in which the patients were symptom-free and working three years and one and a half years after operation); the other was that the specifications of the dicetylphosphate containing cellophane became known, and this has been used

33. Scott, W.: Abdominal Aneurysms: A Report of 96 Cases, Am. J. Syph., Gonor. & Ven. Dis. **28**:682, 1944.

34. At an exploration six months later, the cutis graft had been completely absorbed.

in Cases 8 and 10, although talcum was added in the former. In Case 7 the cellophane containing dicetylphosphate was used after quartz dust, an asymmetrical crystal with fibrosing properties, was placed on the neck of a high abdominal aneurysm. The patient died within a week with increasing uremia. While autopsy was not done, the involvement of the renal vein in the inflammatory reaction is a possible explanation for the fatality. Since, in the meantime, the favorable results of Cooper and others [9d] and of Blakemore [8] have become known, we are now favoring the combination of an irritant central banding with partial constriction, preferably with rubber. Rubber alone has produced erosion and fatal hemorrhage. In the

TABLE 4.—*Surgical Treatment of Abdominal Aneurysms*

Method	No. of Cases	Results
Electrothermic coagulation	1 (wired twice)	Died after cordotomy
Cellophane collar	2	1 died, 14 mo.; 1 died, 8 mo. (heart failure)
Cellophane collar and wrap	2	1 died, 24 mo.; 1 active and working for 4 yr., then died of coronary occlusion
Cellophane collar and talcum	2	1 works full time, 3 yr.; 1 works full time, 4 yr.
Cellophane collar and quartz	1	Died of uremia 7th day postoperatively
Cellophane collar and wire pack	1	Leakage continued; died 2 wk. postoperatively
Cutis graft	1	Pain relief, 1 yr.; frequent decompensation
Total	10	Died 6 Alive and improved 4 10

TABLE 5.—*Nonsurgical Group of Abdominal Aneurysms*

Case	Age	Sex	Cause	Reasons for Nonoperative Treatment	Result	Survival After Diagnosis
1	57	M	Hypertension, arteriosclerosis	Ruptured before entrance	Died	3 wk.
2	57	M	Hypertension, arteriosclerosis	No surgical consultation	Died	3 yr.
3	62	M	Severe hypertension, arteriosclerosis	Cord lesion, myocardial infaret	Died	2 yr.
4	72	M	Arteriosclerosis	Several coronary occlusions; both femorals closed	Died	2 yr.
5	58	M	Hypertension, arteriosclerosis	Coronary insufficiency, attending internist refused operation	Died	Ruptured 3 yr. later
6	51	F	Arteriosclerosis	Ruptured while under study in another department	Died	1 wk.
7	..	M	Arteriosclerosis	Age, general debility, cord paralysis	Died	2 mo.

last case (No. 10), seen in consultation with Dr. B. C. Kilbourne, the aneurysm extended well beyond the level of the left renal vein and a complete encirclement of the neck could not be carried out, so that a pack of cold wire was placed against the neck of the aneurysm. In this case the operation was done on a patient with a poor myocardium who had had a massive, shortly fatal, leak into the left retroperitoneal fossa and who was certainly not in a condition to warrant an aneurysmorrhaphy.

Of the 10 patients listed in Table 3, Patients 4, 5, and 9 have lived for one, three, and four years, respectively; Patient 5, with a cutis graft (and severe cardiac disease) will never be rehabilitated and may die from cardiac disease. Table 4 illustrates the various methods used and again points to the importance of combining several methods. Equally instructive is the list of patients not operated on shown

in Table 5. All seven patients died during our period of observation. In Cases 1, 6, and 7 a leak occurred, and the patients died within a short time, although there always seems to be a week or two during which emergency procedures could be instituted, as was done in Case 10, listed in Table 1. In Cases 2 and 5 surgery was not considered by the internist. In Cases 3, 6, and 7 cord changes were present, with complete or partial paralysis of the lower extremities. Patient 4 was 72 years old and had so much generalized arteriosclerosis that operation seemed futile.

Of the patients who died some time after surgical therapy, an autopsy report is available on only one to illustrate the effect of the cellophane band (Case 3 in Table 3), and the report of Dr. Granville A. Bennett, head of the Department of Pathology, University of Illinois College of Medicine, is hereby appended in part.

Autopsy A (Special Sections of Aneurysm).—1. This large celloidin section represents a transverse section through the entire abdominal aneurysm below the point at which the

Fig. 4.—Celloidin section through the abdominal aneurysm below the point at which the cellophane collar was applied. The lumen has been remarkably narrowed, and between the thin wall and the residual lumen there is a third layer of thrombus and atheromatous debris.

cellophane was applied. Externally the aneurysm measures 5.6 cm. in width and 4.5 cm. in thickness. The section reveals that the remnants of the aortic wall are markedly thin, measuring up to 1 mm. in thickness. Between this wall and the residual lumen of the aorta is a thick layer of thrombus and atheromatous debris. Together, this layer measures approximately 2 cm. on the ventral aspect. The atheromatous material is sharply delineated from the thrombus and measures 5 to 8 mm. in thickness. The residual aortic wall, consisting of thin, stretched, frequently disrupted, attenuated smooth muscle bundles and disrupted lamina, exhibits marked calcification in places and considerable ingrowth of blood vessels surrounded by inflammatory cell infiltrations. The adventitial layer contains a few lymph nodes, compressed nerves, and numerous blood vessels of small and medium size. Several good-sized arteries in the adventitia show occlusion of their lumina by organized and partially canalized thrombi. Pronounced diffuse and focal lymphoid plasma-cell infiltration of the adventitial layer is seen. The interior of the markedly altered aortic wall gives way abruptly to a huge mass of atheromatous debris in which cholesterol clefts are numerous and calcareous deposits are common. Superimposed on the interior of the atheromatous plaque is the large thrombotic mass referred to above. This is in part formed of dense inspissated fibrin, but interiorly a recent

variegated thrombus has been superimposed. The changes observed in this section show no qualitative or quantitative differences from those that may be observed in an abdominal aneurysm of this dimension which has not been treated with cellophane constriction.

2. This large celloidin section is a longitudinal one, including a portion of the aorta above the cellophane constriction and an equal segment (2 cm. in length) of aortic wall and thrombus below the cellophane band. The cavity which at the time of autopsy inclosed the cellophane band is clearly apparent and is lined with granulation tissue heavily infiltrated by all forms of inflammatory cells, lymphocytes predominating. Much extravasated blood and a large amount of hemosiderin pigment are also present. There are also collections of lipid-containing phagocytes. Fibrous tissue, which is undergoing hyalinization in the more peripheral parts, appears to be greatly increased about the margins of the cellophane capsule. Thrombosed blood vessels

Fig. 5.—Aneurysm of the abdominal aorta; specimen obtained at autopsy. Note the widened aorta with calcified plaques and a sudden decrease in diameter. The cellophane bands are partly visible at the level of the small wooden pegs. There is a narrow central lumen lined with partially organized mural thrombus, which in turn is surrounded by a thick, calcified, partly atheromatous wall. The lesion extended to the iliac bifurcation, which is beyond the bottom of the picture. (From de Takats, G., and Reynolds, J. T.: The Surgical Treatment of Aneurysms of the Abdominal Aorta, Surgery **21**:443 [April] 1947.)

undergoing thrombosis are frequently seen. The aortic wall above the cellophane band shows pronounced arteriosclerotic changes, with enormous intimal plaques containing extensive calcification. These plaques extend outward into the media and at times involve the entire medial coat, reaching to the adventitial layer. There is a good deal of vascularization, and round-cell infiltration is observed. These same changes in the aortic wall are visible below the level of the cellophane band. In this segment, however, there is more complete destruction of the aortic wall and more fibrosis in the adventitial layer. The chief difference between the two portions

of the aortic wall is that below the level of the cellophane band an enormous thrombus has been superimposed on the atheromatous plaque. It is this thrombus that is described above under Section 1.

From this report it would seem that a thrombus had recently occluded the lumen of the aorta below the cellophane band. This, of course, is a desirable solution but whether or not the cellophane constriction accelerated this process is impossible to say. Actually, the lumen was practically occluded (Fig. 5).

COMMENT

This, then, is the account of our trials and attempts to salvage a small group of patients whose condition was considered beyond repair in the past. On the basis of our experience to date we feel that the cellophane bands applied to the neck should be constricted to throttle the blood flow, preferably by elastic material; that the cellophane, unless it contains dicetylphosphate or is rubbed with talcum,[35] is inert and useless; that quartz is highly irritating and possibly toxic, and that a wire pack, placed toward the neck of the sac, may be a useful adjunct to impede blood flow but the costly and complicated electrothermic coagulation with measurements of blood flow is often not applicable in most surgical centers.

At the present time the combination of external elastic compression with rubber wrapped in the irritant type of cellophane, reinforced by a large cold wire pack, seems to be safe enough for the average elderly, sclerotic, handicapped patient. An occasional sac extending above the renal vein may limit the usefulness of proximal constriction. Excision of the sac with reconstruction will have to be limited to a few patients whose general status is excellent or whose aneurysm is traumatic. A restorative endoaneurysmorrhaphy would be, of course, the ideal procedure.

SUMMARY

Ten patients with aneurysms of the abdominal aorta have been operated on in an application of the principle of intrasaccular wiring, perisaccular production of fibrosis, or proximal banding and their combinations. Of these, four patients are alive and have improved for a period of one to four years. Another group of seven patients not operated on have been followed, all of whom are dead. While the results are far from satisfactory, enough data have been assembled to warrant a further attempt, possibly with a more direct surgical approach to the sac.

35. Talc U. S. P. (magnesium silicate).

ACUTE DIVERTICULITIS OF THE CECUM

A Report of Four Cases and Review of One Hundred Fifty-Three Surgical Cases

JAMES LAURIDSEN, M.D.
AND
FREDERICK P. ROSS, M.D.
BOSTON

AMONG 6,114 surgical patients admitted to the Veterans Administration Hospital, West Roxbury, Mass., four cases of diverticulitis of the cecum were encountered in the 18 months ending March 1, 1951. Since this disease is not common, these four cases are reported along with a brief review of the literature on this subject.

Only 149 other surgically proved cases were found after a careful search of the available literature. However, diverticulitis of the cecum may be commoner than is generally realized, and therefore the available information is worth reviewing.

REPORT OF CASES

CASE 1.—A 23-year-old clerk entered the hospital on Aug. 23, 1949, with right lower quadrant pain of four days' duration. There had been no nausea or vomiting.

Physical examination revealed spasm, tenderness, and rebound tenderness in the right lower quadrant. The temperature was 99.6 F., peristalsis was normal, and no mass was palpable. There was high right rectal tenderness. The white blood cell count was 12,900, with 78% polymorphonuclear cells, and the urine was normal. A preoperative diagnosis of acute appendicitis was made.

At operation a single diverticulum of the cecum containing a fecalith was found just above the level of the appendix on the lateral edge of the cecum. A partial resection of the cecum and appendectomy were done.

Pathological study revealed a normal appendix and a diverticulum of the cecum with acute inflammatory reaction. The ostium measured 1.8 cm. in diameter, and the cavity was 1 cm. deep. It was a true diverticulum, with muscular layers present. The postoperative course was uneventful and the patient was discharged on the 16th postoperative day.

CASE 2.—A 29-year-old man entered the hospital on Dec. 28, 1949, because of vague lower abdominal pain of 48 hours' duration. The pain had gradually localized to the right of the umbilicus. There had been no nausea or vomiting. There had been intermittent diarrhea and constipation of four to five years' duration and occasional bright blood in the stool for two years. Appendectomy had been done at the age of 10.

Physical examination revealed marked tenderness to the right of the umbilicus. A small tender mass was palpable in this area, and was interpreted as a distended gall bladder. The

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temperature was 101.6 F., the white blood cell count was 20,000 with 94% polymorphonuclear cells, and the urine was normal.

A preoperative diagnosis of acute cholecystitis was made and early operation performed. Through a right subcostal incision the gall bladder and upper abdominal organs were examined and found to be normal. There was purulent fluid in the peritoneal cavity. Just above the ileocecal valve was a firm inflammatory mass consisting of omentum and mesentery plastered against the colon. This was interpreted as a perforation of the cecum, with local inflammatory reaction, and a resection of the distal ileum, cecum and part of the ascending colon with ileotransverse colostomy was carried out.

Pathological examination revealed a diverticulum of the cecum, with acute inflammatory changes, and perforation resulting in an abscess walled off by the omentum and mesentery. The postoperative course was complicated by stubborn wound sepsis requiring incision and drainage and later excision of a sinus tract, with eventual healing.

CASE 3.—A 42-year-old man entered the hospital on June 12, 1950, with right lower quadrant abdominal pain and nausea of 18 hours' duration.

There was tenderness over McBurney's point, with rebound tenderness and referred rebound tenderness. A small tender mass was palpable just below McBurney's point. The temperature was 99.6 F., and the leucocytes numbered 18,400, with 88% polymorphonuclear forms.

A preoperative diagnosis of acute appendicitis was made and operation carried out. The appendix was found to be normal and was removed. There was a firm mass in the wall of the cecum 1 in. (2.5 cm.) in diameter just below the appendix. This lesion was resected along with a small margin of surrounding cecum.

Pathological study revealed a normal appendix and an acutely inflamed diverticulum of the cecum, with a 0.3 cm. ostium and a 1.0 cm. cavity containing no fecalith. It was a true diverticulum including muscular layers. Postoperatively the patient did well and was discharged on the 12th postoperative day.

CASE 4.—A 31-year-old man was hospitalized on Feb. 2, 1951, for study and treatment of chronic rheumatic heart disease. While he was on the medical service, right lower quadrant pain suddenly developed, intensified by moving. There was no nausea, anorexia, or vomiting.

Examination six hours after the onset of pain revealed moderate tenderness deep in the right lower quadrant, with rebound and referred rebound tenderness. No mass was palpable, and rectal examination gave negative results. The temperature was 99.4 F. and the white blood cell count 16,200, with 76% polymorphonuclear cells. A preoperative diagnosis of acute appendicitis was made and immediate operation undertaken.

At operation the appendix appeared normal. A careful abdominal exploration was done and no abnormality found except for a 1.0 by 0.5 cm. indurated diverticulum arising from the medial aspect of the cecum 2 cm. above the ileocecal valve. The appendix and diverticulum were both excised at their bases. No fecalith was present. Pathological study revealed acute inflammation in a diverticulum containing muscular layers.

Convalescence was uneventful, and the patient was discharged on the eighth postoperative day.

The preoperative diagnosis of acute appendicitis was made in three cases on the basis of symptoms, signs, and laboratory findings consistent with that disease. The fourth patient had undergone a previous appendectomy, and the finding of a tender mass high in the right side led to the preoperative diagnosis of acute cholecystitis.

At operation the presence of an acutely inflamed diverticulum of the cecum was obvious in two cases. Simple excision of one was done, and one patient underwent excision, with the removal of a rim of normal cecum to permit closure of the defect with tissue not involved in the inflammatory reaction. The third diverticulum was believed to be a local tumor and was removed by partial cecectomy. In the remaining case the operative diagnosis of perforated cecum with local inflammatory reaction was made and partial colectomy performed. Only in this case were postoperative complications encountered.

COMMENT

A review of the available literature was undertaken, and a total of 149 surgically proved cases were found. All these cases were summarized from the original literature except for six cited by Anderson and reported by the four authors Shimizu, Delitala, Fasano, and Thomsen. In these four cases the original papers were not available. Outstanding among many excellent papers was that of Anderson, who summarized 91 cases and added 8 more from the Mayo Clinic. Three of the cases, however, have been excluded from our series. These include two cases reported by Bryan and excluded because of indefinite pathological description and one reported by O'Callaghan and excluded because of the location of the lesion.

These 149 cases plus the 4 cases from our clinic were tabulated according to sex, age, symptoms, physical findings, temperature, laboratory findings, preoperative and postoperative diagnosis, operations, and results. The diverticula were studied as to size, location, histology, and presence or absence of fecalith and perforation.

Age and Sex.—The average age of the 84 men was 40.4 years or essentially the same as the average for the 64 women, 40.8 years. In five cases the sex was not reported. The age range was from 10 to 72 years. The median age was 39.

The average age of these patients, 40.6 years, is much less than the average age of patients having the commoner type of multiple or acquired diverticulitis of the colon. Pemberton and others reported an average age of 53.6 years in a series of 144 patients undergoing surgery for diverticulitis of the sigmoid colon. The considerable male preponderance of 2:1 seen in acquired diverticulitis is also lacking in the cecal form under discussion here.

Diagnosis.—After a tabulation of the symptoms, signs, physical findings, and laboratory findings in the 153 cases, a marked similarity to those of acute appendicitis was noted (Reid, Poer, and Merrell). The only significant difference in the clinical course between the two groups of patients was that nausea occurred in only 27% of the cases of acutely inflamed cecal diverticula as compared with 78% among the cases of acute appendicitis, and vomiting occurred in only 16% of the diverticulitis cases as compared with 73% of appendicitis cases.

It is not surprising, therefore, that the preoperative diagnosis was appendicitis in practically all cases except those in which the appendix had been previously removed.

Diagnosis, Preoperative and Operative (Table 1): Of the 135 cases in which a preoperative diagnosis was stated, 115, or 85.2%, had the diagnosis of appendicitis with or without perforation. Of the remaining 20 patients, the majority had undergone a previous appendectomy and other diagnoses were made as indicated in Table 1. In the 4 cases with a correct diagnosis preoperatively, there was x-ray visualization of a diverticulum by barium enema in all and two patients had previously undergone appendectomy.

The diagnosis at operation also presented certain difficulties. In many cases the local indurative inflammatory reaction simulated the induration of a malignant process. Because of this the correct diagnosis at operation was made in only 89, or 69.9%, of the cases in which an operative diagnosis was reported. In 39 cases, or 29.3%, the incorrect diagnosis of malignant disease, or possible malignant disease, was made.

Operations Performed and Mortality (Table 2).—The operative procedures carried out in the 153 cases are summarized in Table 2. Of the six cases listed under "other operations," in one adhesions were cut, in four appendectomy only was performed, and in the remaining one (Conway and Hitzrot) closure by a "Z" suture of a perforated diverticulum was performed and resulted in a fatality due to peritonitis.

As may be seen from the table, partial colon resection of some sort was carried out in 57 of the 153 cases. In only 35 of these, however, was the partial colon

TABLE 1.—*Diagnosis, Preoperative and Operative*

	Preoperative		Operative	
1. Appendicitis	115	85.2%	0	0
2. Malignant disease	5	3.7%	39	29.3%
3. Diverticulitis	4	3.0%	89	66.9%
4. All others	11	8.1%	5	3.8%
A. Cholecystitis	3		0	
B. Abscess	3		3	
C. Pelvic inflammatory disease	3		0	
D. Hernia	1		1 Ulcer 1 T. B.	
E. Meckel's diverticulum	1		0	
Total reporting	135		133	
Unknown	18		20	
Total	153		153	

TABLE 2.—*Mortality Rate*

	Mortality			
			Died	
Operation	No. of Cases	Reporting Results	No.	%
1. Excision	67	62	1	1.6
2. Colon resection	57	55	4	7.3
A. Right colectomy	34	32	3	9.4
B. Cecectomy	16	16	1	6.3
C. Ileocecal resection	7	7	0	0
3. Inversion	10	10	0	0
4. Drainage	8	8	1	12.5
5. Exteriorization	5	5	0	0
6. Other	6	6	1	16.6
Total	153	146	7	4.8

resection done because of suspected malignant disease. In the other cases in which resection was performed the correct diagnosis was made but the inflammatory reaction was such that an operation more radical than local excision seemed indicated to obtain sutural apposition of noninvolved tissue.

The number of deaths among the 146 cases in which results were reported was 7, or 4.8%. The mortality in the 68 cases of simple excision was 1.6%. There were four deaths, or 7.3% mortality, among patients undergoing partial colonic resection, and all of them occurred in the group in which an incorrect diagnosis of cancer was made at operation. In seven of the 153 cases the final result was not stated.

Fate in 39 Cases with Incorrect Diagnosis of Cancer at Operation (Tables 3 and 4).—Of special interest are the 39 cases in which an incorrect diagnosis of malignant disease was made at operation, and these have been separated from the rest of the series for study. As may be noted from Table 3, 35 of the patients were subjected to partial colon resection, with four deaths, an 11.4% mortality. The remaining four underwent other procedures, with no fatalities. This leaves a total mortality of 10.3% for the 39 cases with an incorrect diagnosis of cancer.

TABLE 3.—*Fate in 39 Cases with Incorrect Diagnosis of Cancer at Operation*

	Cases	Mortality	
		No.	%
Right colectomy	25	3	12.0
Cecectomy	7	1	14.3
Ileocecal resection	3	0	0
(Total) Colon resections	35	4	11.4
Excision	2	0	0
Exteriorization	2	0	0
Total	39	4	10.3

TABLE 4.—*Group Mortality Rate*

Mortality in Cases with Correct Diagnosis of Diverticulitis at Operation	Mortality in Cases with Incorrect Diagnosis of Cancer at Operation	Total Group Mortality, 146 Cases
2/89	4/39	7/146*
2.2%	10.3%	4.8%

* Includes 1 case (Sartor) with diagnosis of pericecal abscess at operation.

TABLE 5.—*Fatal Cases*

Author	Preoperative	Operative Diagnosis	Operation	Cause	Day
1. Conway	.....	Cancer	Right colectomy	Pneumonia	3
2. Conway	Appendicitis	Diverticulitis	Close perforated Diverticulum	Peritonitis	2
3. Gant	"Neoplastic TB"	Diverticulitis	Excision	"Exhaustion"	28
4. Porter	Cancer	Cancer	Right colectomy	Gangrene	6
5. Schnug	Appendicitis	Abscess	Drained	Pneumonia	14
6. Tschudi	Appendicitis	Cancer or tuberculosis	Cecectomy	Infarction	4
7. Collins	Appendicitis	Cancer	Right colectomy	Peritonitis	?

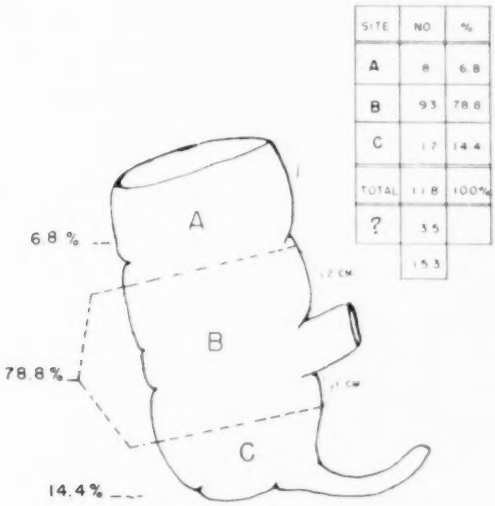
As may be seen in Table 4, this 10.3% mortality compares rather unfavorably with the 2.2% mortality in the 89 cases with a correct diagnosis and the 4.8% mortality for the entire series.

Table 5 is self-explanatory and lists the cause of death in each of the seven fatal cases.

Site of Lesion.—The drawing indicates that most of the diverticula are near the level of the ileocecal valve. If lines are drawn 2 cm. above the valve and 1 cm. below it, 78.8% of the lesions occur in this area.

Pathologic Process (Table 6).—A fecalith was present in more than half of the cases. Of 104 cases in which a pathologic report was made, a fecalith was present in 57, or 54.8%. In most of these the cavity of the diverticulum was almost completely filled with the concretion, suggesting that a barium enema might not be an effective means of visualizing the lesion. Perforation was present in only 29 cases. In only six cases was more than one diverticulum present.

The histology of the diverticular wall is of interest since, unlike what happens in the commoner acquired diverticulitis of the colon, all muscular layers are



Site of lesion.

TABLE 6.—*Pathologic Process*

	Present	Absent	Total Reporting	Unknown	Total
Fecalith	57 54.8%	47 45.2%	104	49	153
Perforation	29 21.0%	109 79.0%	138	15	153
True diverticulum *	41 71.9%	16 28.1%	57	96	153

* Average ostium size, 0.90 cm. (31 reporting); average diverticulum size, 2.73 cm. (81 reporting).

present. In 57 cases in which the pathological report gave sufficient detail for evaluation, 41 of the lesions, or 71.9%, were true diverticula with all muscular layers in the walls. Fragments of the muscular layers were noted in several of the remaining 16 cases, suggesting that these layers may have originally been present but were partially destroyed by pressure necrosis and local inflammatory reaction.

Etiology.—The usual theories concerning the etiology of ordinary multiple diverticulitis of the colon were applied to diverticulitis of the cecum in the older literature. However, as cases of cecal diverticulitis have accumulated since 1912

it has become evident that this disease is probably entirely different from ordinary colonic diverticulitis and diverticulosis and has a separate etiological background. Multiple diverticula of the common type are false diverticula, since the walls usually contain only mucosa and serosa. They occur most commonly in the sigmoid colons of men past 45 years of age. In the cecal type of diverticulum muscular layers are commonly found. The lesion is usually a solitary one, and it occurs in a lower age group. All this suggests that an embryological remnant or defect is the basis of this lesion.

The embryological theory of origin has been discussed by Waugh, Cave, Kelly and Hurdon, and Gladstone and Wakely. According to these investigators, an outgrowth from the tip of the cecum occurs in the embryological development of the gut and this outgrowth enlarges during the sixth week and atrophies toward the end of the seventh week or soon thereafter. This observation was first reported by Kelly and Hurdon in 1905 from a study of the region in more than 50 human embryos from the Mall and Brödel collection. It was later confirmed by Gladstone and Wakely in 1925. They referred to this structure as the "transient appendix." They pointed out that the structure simulates the true appendix in position but that since it later atrophies and completely disappears it is probably an independent structure not connected directly with the permanent appendix, which is differentiated later.

Improvement of Operative Diagnosis.—In studying the cases in this series, we were impressed with the difficulty encountered by experienced surgeons in making an accurate diagnosis at operation. The discussions of the various authors were accordingly examined for advice regarding ways to facilitate the operative diagnosis. The papers of McVay and of Graves were especially helpful. McVay states that cecal lesions in order of frequency are carcinoma, tuberculosis, actinomycosis, and diverticulitis. These were ruled out in order of frequency of occurrence. Malignant changes may be evident by cauliflower projections into the lumen, direct extension along and into the bowel wall, and punched-out ulcers palpable inside the bowel lumen. A lymph node or portion of questionable tissue may be removed for frozen section. A further maneuver of value is that recommended by Graves and others, who advise palpating the ostium of the diverticulum through the opposite wall of the cecum. This method has been of value to several operators, especially when a fecalith has been present.

SUMMARY

Four recent cases of inflammation of a single diverticulum of the cecum have been presented as an addition to the 149 cases previously reported in the available literature. An attempt was made to analyze these cases in order to understand better this uncommon but not rare clinical entity.

Preoperatively the symptoms, signs, and physical findings were those found in appendicitis. There was a slight male preponderance of 84:64, with an average age of 40.6 years and a median age of 39. Of the cases (14.8%) in which a diagnosis of appendicitis had not been made, a previous appendectomy had been performed in most.

The diagnosis at operation in some cases was difficult because the inflammatory reaction simulated a malignant process. The correct operative diagnosis was made in only 66.9% of the cases.

Local excision is the operation of choice and was done in 67, or 43.8%, of the 153 cases. The other operations are discussed and include 57 partial colonic resections.

The total group mortality was 4.8%. However, the incorrect diagnosis of malignant disease led to unnecessarily radical surgery and resulted in a mortality rate more than twice that of the cases in which treatment was by simpler means. Mortality in the local excision group was 1.6%, as compared with 7.3% in those undergoing colon resection. In the 39 cases with an incorrect diagnosis of malignant disease at operation a total of 35 colon operations were performed, with an 11.4% mortality. The 89 cases with a correct diagnosis at operation enjoyed a favorable mortality rate of 2.2%.

The site of the lesion was preponderantly (78.8%) at the level of the ileocecal valve or immediately above or below it. There was more than one diverticulum in only 6 cases. The average diverticulum had an 0.9 cm. orifice and a greatest circumference of 2.7 cm. Of the cases in which the histologic findings were reported, most, or 71.9%, were examples of true diverticula containing muscle layers.

It seems probable that this disease is of embryologic origin and not related to the commoner acquired diverticulosis of the colon. To facilitate the operative diagnosis, one should make frequent use of frozen sections and carefully palpate the lesion through the opposite cecal wall. By such palpation the diverticular ostium may be palpated. The fecalith which is present in more than half of the cases may be similarly felt.

CONCLUSIONS

1. Acute diverticulitis of the cecum is an uncommon but not rare clinical entity indistinguishable preoperatively from appendicitis.

2. The operative diagnosis is often difficult because of the similarity of the gross appearance of the lesion to carcinoma.

3. The usual lesion is present close to the level of the ileocecal valve, 0.9 by 2.8 cm. in size, rarely multiple, and contains a fecalith in more than half of the cases.

4. Most cecal diverticula are congenital, and the walls contain muscle layers.

5. Local excision is the operation of choice.

6. It is expected that the operative mortality will decrease as the true identity of this lesion is recognized oftener at operation and local excision is more frequently employed.

ADDENDUM

Since this paper was submitted, two more patients with diverticulitis of the cecum have been encountered at the West Roxbury Veterans Administration Hospital. In the first of these, the patient was treated by simple incision of the diverticulum and had an uneventful recovery.

The second case was that of a 30-year-old man in whom the diverticulum and its inflammatory reaction were so close to the ileocecal valve that closure after operation would have been hazardous. For this reason, and to avoid the ileocecal resection, a large cecostomy tube was inserted into the cecal defect after the edges of the defect had been sutured to the peritoneum. The tube was removed on the eighth day, and the cecostomy opening closed satisfactorily. However a small wound sinus appeared and was later excised before final healing occurred.

BIBLIOGRAPHY

Abel, L.: Diverticulitis of Caecum, Resembling Carcinoma, Proc. Roy. Soc. Med. **32**:401, 1938.

Anderson, L.: Acute Diverticulitis of the Cecum, Study of 99 Surgical Cases, Surgery **22**:479-488, 1947.

Perforated Diverticula of the Cecum with Peritonitis, Proc. Staff Meet., Mayo Clin. **21**:465-469, 1946.

Bagetti, H.: Diverticulitis Solitaria del ciego: Segunda observacion, Bol. y trab. Soc. argent. cirujanos **4**:32, 1943.

Baker, J. W., and Carlile, T.: Solitary Diverticulitis of the Cecum, J. A. M. A. **122**:354-356 (June 5) 1943.

Barbier, M.: Typhylite gangréneuse localisée à point de départ diverticulare, Mém. Acad. chir. **64**:614-619, 1938.

Bearse, C.: Acute Perforative Diverticulitis of the Colon in Young Persons, J. A. M. A. **113**:1720-1722 (Nov. 4) 1939.

Beck, W. C., and Hopkins, G. S.: Solitary Diverticulitis of the Cecum: Report of 5 Cases, Guthrie Clin. Bull. **17**:12-14, 1947.

Bennett-Jones, M. J.: Primary Solitary Diverticulitis of the Caecum: A Report of 3 Cases, with a Review of 17 Recorded Cases, Brit. J. Surg. **25**:66-76, 1937.

Bryan, W. A.: Simple Inflammatory Lesions of the Cecum, Tr. South. S. A. **43**:320-330, 1930.

Burgess, C. M.: Diverticulitis of the Cecum, Am. J. Surg. **50**:108-111, 1940.

Busch, I., and Friedfeld, L.: Solitary Diverticulitis of the Cecum, Am. J. Surg. **57**:555-557, 1942.

Bryne, J. J.; Kallan, A. C., and Bassett, A. A.: Acute Diverticulitis of the Cecum: A Report of 5 Cases, J. A. M. A. **144**:823-826 (Nov. 4) 1950.

Carroll, H. B.: Solitary Diverticulitis of the Cecum and Ascending Colon, Quart. Bull. Northwestern Univ. M. School **17**:196-202, 1943.

Cave, A. J. E.: Appendix Vermiformis Duplex, J. Anat. **70**:283-292, 1936.

Chanock, F., and Madden, P. C. W.: Solitary Diverticulitis of the Caecum, S. African Med. J. **18**:12, 1944.

Collins, D. C.: Acute Diverticulitis of the Cecum Simulating Carcinoma: Report of 10 Cases, Ann. West. Med. & Surg. **4**:6, 294-297, 1950.

Conway, F. M., and Hitzrot, J. M.: Diverticulitis of the Colon: Report of 36 Cases from the New York Hospital, Ann. Surg. **94**:614-639, 1931.

Cooke, A. B.: When Appendicitis Is Not Appendicitis: A Case of Diverticulitis of the Cecum, J. A. M. A. **78**:578-579 (Feb. 25) 1922.

Costin, M. E., and Gaston, E. A.: Solitary Diverticulum of the Cecum, Arch. Surg. **60**:743-748 (April) 1950.

Dalger, M. M., and Coureaud: Un cas de diverticulite aiguë perforante du cæcum. Bull. et mém. Soc. nat. de chir. **53**:751-753, 1927.

d'Argencourt, G.: La chirurgie en province: Diverticule solitaire du cæcum, Union méd. Canada **73**:660-661, 1944.

Delitala, P.: Diverticulitis, with Report of a Case, Studi sassaresi **17**:124-128, 1939; cited by Anderson.

Doppler, cited by Tschudi.

Dorling, G. C.: Solitary Diverticulum of the Caecum, Brit. M. J. **1**:513-514, 1945.

Epstein, S.: Diverticulitis of the Cecum, Am. J. Surg. **22**:276-278, 1933.

Fairbank, T. J., and Rob, C. G.: Solitary Diverticulitis of the Cæcum and Ascending Colon, Brit. J. Surg. **35**:105-107, 1947.

Fasano, M.: Diverticulo del cieco, Boll. et mém. Soc. Piemontese di chir. **7**:108-112, 1937; cited by Anderson.

Fifield, L. R.: Diverticulitis, Lancet **1**:277-281, 1927.

Fossati, A.: Diverticulitis solitaria del ciego, Arch. urug. med. **20**:343-348, 1942.

Freeman, L.: Diverticulum of Cecum, Tr. West. S. A. 1928, p. 78.

Frehling, J. M.: Diverticulitis of the Cecum, with Report of a Case, Kentucky M. J. **31**:152-157, 1933.

Frehling, S.: Diverticulitis of the Cecum: A Method of Management, Ann. Surg. **121**:83-87, 1945.

French, R. W.: Diverticulitis of the Cecum, with Report of 3 Cases, Boston M. & S. J. **189**:307-309, 1923.

Fritz, L. H.: Solitary Diverticulitis of Cecum, J. Iowa Med. Soc. **33**:470-472, 1943.

Gabriel, W. B.: Diverticulitis of the Caecum, Proc. Roy. Soc. Med. **31**:691, 1937.

Gant, S. G.: Diverticula, Diverticulitis and Peridiverticulitis of the Small Intestine, Cecum, Colon, Sigmoid Flexure and Rectum, J. A. M. A. **77**:1415-1420 (Oct. 29) 1921.

Gatewood, J. W.: Solitary Diverticulitis of the Cecum: Report of 2 Cases, Ann. Surg. **122**:52-58, 1945.

Gladstone, R. J., and Wakely, C. P. G.: Relative Frequency of the Various Positions of the Vermiform Appendix: As Ascertained by an Analysis of 3,000 Cases, with an Account of Its Development, Brit. J. Surg. **11**:503-520, 1924.

Gordon-Taylor, G.: Solitary Diverticulum of the Caecum, Proc. Roy. Soc. Med. **32**:896-897, 1938.

Grace, A. J.: Primary Solitary Diverticulitis of the Caecum, Brit. J. Surg. **26**:200-201, 1938. Acute Solitary Diverticulitis of Caecum: Report of a Case, Surgery **7**:232-235, 1940.

Graves, W. N.: Solitary Diverticulitis of the Cecum, Minnesota Med. **21**:615-617, 1938.

Greensfelder, L. A., and Hiller, R. I.: Caecal Diverticulosis, with Special Reference to Traumatic Diverticula, Surg., Gynec. & Obst. **48**:786-795, 1929.

Hendtlass, R. F.: Perforated Solitary Diverticulum of Caecum, Brit. M. J. **2**:309-310, 1944.

Henry, F. C.: Acute Diverticulitis of the Cecum: Report of 3 Cases Diagnosed Preoperatively as Acute Appendicitis, Ann. Surg. **129**:109-118, 1949.

Jackson, W. R.: Diverticulitis of the Cecum, New York J. Med. **106**:838, 1937.

Jonas, A., Jr.: Solitary Cecal Diverticulitis, J. A. M. A. **115**:194-197 (July 20) 1940.

Kelly, H. A., and Hurdon, E.: The Vermiform Appendix and Its Diseases, Philadelphia, W. B. Saunders Company, 1905.

Kennon, R.: Diverticulum of the Cæcum, Brit. J. Surg. **20**:521-522, 1933.

Klages, F.: Akute Entzündung eines isolierten Blindarmdivertikels unter dem Bilde der Wurmfortsatzentzündung, Zentralbl. f. Chir. **64**:1090-1093, 1937.

Kron, S. O., and Specter, J.: Acute Diverticulitis of the Cecum, Gastroenterology **15**:62-66, 1950.

Leonardo, R. A.: Primary Solitary Diverticulitis of the Cæcum, Ann. Surg. **91**:540-543, 1930.

Leonardo, R. M.: Double Appendix or Solitary Cecal Diverticulum? J. Internat. Coll. Surgeons **6**:64-70, 1943.

Levin, S.: Solitary Diverticulitis of the Caecum, S. African M. J. **24**:520-521, 1950.

Levine, R. M.: Acute Solitary Diverticulitis of the Caecum, Canad. M. A. J. **61**:63-64, 1949.

McBee, P.: Acute Diverticulitis of the Right Colon, South. Med. & Surg. **102**:111-113, 1940.

McVay, J. R.: Diverticulum of the Cecum, Case Report with Operative Differential Diagnosis, Tr. West. S. A. 1928, pp. 67-78.

McWhorter, G. L.: Acute Diverticulitis of the Cecum: Right-Sided Symptoms with Diverticulitis of the Sigmoid, S. Clin. North America **14**:901-908, 1934.

Masson, J. C.: Diverticulitis of the Large Bowel, Canad. M. A. J. **11**:106-111, 1921.

Migliacio, A. V.: Acute Diverticulitis of the Cecum: Report of 6 Cases, Rhode Island M. J. **32**:255-259, 1949.

Mirvish, L.: Diverticulitis of the Cæcum, Clin. Proc. **5**:354-359, 1946.

Moschowitz, A. V.: Acute Gangrenous Perforated Diverticulitis of the Caecum, Ann. Surg. **67**:624, 1918.

Nair, T. D.: Primary Diverticulitis of the Caecum, Indian J. Surg. **7**:133-134, 1945.

Nash, E. C., and Palmer, W. L.: The Clinical Significance of Diverticulosis, Including Diverticulitis of the Gastro-Intestinal Tract, Ann. Int. Med. **27**:41-62, 1947.

Nocito, F. J., and Cottini, G. F.: Diverticulo solitario del ciego a forma seudotumoral, Rev. Asoc. méd. argent. **62**:44-45, 1948.

Noon, Z. B., and Schenk, H. L.: Solitary Diverticulitis of the Cecum, Am. J. Surg. **68**:364-368, 1945.

Obenour, S. W.: Gangrenous Diverticulum Associated with Suppurative Appendicitis, Ohio M. J. **34**:175-176, 1938.

O'Callaghan, R.: Diverticulum of the Ascending Colon, Surg., Gynec. & Obst. **33**:679-680, 1921.

Oldquist, B., and Petrén, T.: Ein Fall von angeborener Divertikelbildung des Blindarms, Arch. path. Anat. **280**:581-586, 1931.

Owings, J. C., and Morgan, Z.: Solitary True Diverticulum of the Cecum: Report of a Case, Surgery **8**:662-664, 1940.

Pemberton, J. de J.; Black, B. M., and Maino, C. R.: Progress in the Surgical Management of Diverticulitis of the Sigmoid Colon, Surg., Gynec. & Obst. **85**:523-534, 1947.

Perazo, R. R.: Diverticulosis solitaria del ciego, Prensa méd. argent. **34**:1717-1719, 1947.

Periera, H.: Diverticulitis of the Caecum, Brit. M. J. **1**:279, 1927.

Pessagno, D. J.: Diverticulitis of the Cecum, Bull. School Med. Univ. Maryland **20**:59-61, 1935.

Porter, M. F.: Enteroliths and Diverticula, Especially Enteroliths Contained in Diverticula of the Large Bowel: Report of a Case, Surg., Gynec. & Obst. **41**:185-186, 1925.

Potier, F.: Diverticulité et appendicité, Bull. et mém. Soc. anat. de Paris **137**:29-31, 1912.

Reid, R. M.; Poer, H. O., and Merrell, P.: Statistical Study of 2,921 Cases of Appendicitis, J. A. M. A. **106**:665-669 (Feb. 29) 1936.

Rogers, F. L., and Hilton, D. C.: Case of Diverticulitis of the Cecum Simulating Acute Recurrent Appendicitis, Nebraska M. J. **15**:153-155, 1930.

Sammartino, E. S., and Cervini, R. E.: Peritonitis generalizada per diverticulitis cecal gangrenosa, Arch. argent. de enferm. d. ap. digest. y de la nutrición **13**:391-398, 1938.

Sartor, E.: Acute Diverticulitis of the Cecum and Ascending Colon, Acta. chir. scandinav. **99**:485-488, 1950.

Schnug, E.: Acute Diverticulitis of the Cecum, Surgery **13**:282-289, 1943.

Shier, R. V. B.: Acute Diverticulitis of the Ascending Colon, Canad. M. A. J. **39**:264, 1938.

Shimizu, S.: Ein Fall von Blindarmdivertikel, Bull. Nav. M. A. Japan **26**:49-50, 1937; cited by Anderson.

Staley, J. S.: Diverticulum of the Cecum—with Case Report, Virginia M. Monthly **66**:25-31, 1939.

Stetten, D.: Ileocecal Resection for Acute Diverticulitis of Solitary Diverticulum of Ascending Colon, Ann. Surg. **104**:478-480, 1936.

Stewart, A.: Solitary Diverticulitis of the Cæcum, Canad. M. A. J. **23**:675-676, 1930.

Sumii, K.: Ein Fall von Blinddarmdivertikel, Zentralbl. f. Chir. **63**:1465-1468, 1936.

Szabo, O.: Über das Divertikel des Coecum, Arch. klin. Chir. **190**:291-298, 1937.

Thomsen, H.: Coecal Diverticulum, Hospitalstid **78**:45-52, 1935; cited by Anderson.

Tschudi, E., Jr.: Pseudodivertikel des Cæcum mit akuter Divertikulitis und diffuser Perityphlitis und Periappendizitis, Schweiz. med. Wchnschr. **66**:264-266, 1936.

Vernengo, M. J., and Villafañe, E. D.: Diverticulitis solitaria del ciego, Prensa méd. argent. **33**:506-513, 1946.

Visconti, J. A.: Diverticulitis of Ascending Colon Simulating Acute Appendicitis, Am. J. Surg. **32**:376, 1936.

Walkling, A. A.: Acute Diverticulitis of the Colon, Pennsylvania M. J. **44**:1318-1320, 1941.

Waugh, T. R.: Appendix Vermiformis Duplex, Arch. Surg. **42**:311-320 (Feb.) 1941.

Weible, R. E.: Diverticulitis of the Colon, Minnesota Med. **20**:21-28, 1937.

Wilson, F. C.: Diverticulitis of the Cecum, J. M. A. Alabama **1**:282-285, 1932.

SURGICAL MANAGEMENT OF CONGENITAL MALFORMATIONS OF THE ANUS AND RECTUM

Report of One Hundred Eleven Cases

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MINNEAPOLIS

CONGENITAL malformations of the anus and rectum are rather uncommon, but when they do occur it is imperative that they be recognized early and a rational plan of treatment instituted promptly. These anomalies may constitute an immediate danger to the life of the patient when bowel obstruction is complete, or they may cause no impairment of general health and become a source of complications later in life.

HISTORY

Congenital anomalies of the anus and rectum have been observed and reported since antiquity by Greek, Roman, and Arabic physicians. They regarded these anomalies chiefly as objects of medical curiosity, and treatment was considered beyond the scope of surgical capabilities.

In the seventh century Paulus of Aegina recognized a case of imperforate anus and described an operation for its relief. He passed a bistoury through the perineum and later dilated the opening with bougies. In 1640 Scultet reported a case of congenital anal stenosis successfully dilated with gentian roots. Saviard in 1663 recorded the case of a patient with a bulging membranous closure of the rectum that he treated with a bistoury and subsequent dilatation. This method was practiced with little variation until Amussat in 1835 recommended proctoplasty by dissection and mobilization of the rectal pouch to the proper site.

In 1884 French surgeons advised inguinal colostomy when perineal exploration failed. The first successful operation for imperforate anus in the United States was performed by Campbell in 1790. Bodenhamer [1] in 1860 published an exhaustive treatise on anorectal anomalies and presented 287 collected cases. In 1887 Cripps [2] reported 100 cases in which operation was carried out, with a mortality of 50%. By 1915 the mortality had been reduced to 25% in Brenner's [3] series, and there has been no appreciable change in reported series since that time.

Read before the Section on Surgery, General and Abdominal, at the One-Hundredth Annual Session of the American Medical Association, Atlantic City, June, 1951.

1. Bodenhamer, W.: A Practical Treatise on the Ætiology, Pathology and Treatment of the Congenital Malformations of the Anus and Rectum, New York, S. S. & W. Wood, 1860.

2. Cripps, H.: Diseases of the Rectum and Anus, New York, The Macmillan Company, 1914.

3. Brenner, E. C.: Congenital Defects of the Anus and Rectum, Surg., Gynec. & Obst. **20**:585, 1915.

NORMAL EMBRYOLOGY

The normal embryologic development of the anus and rectum, with its segregation from the urogenital tract, follows a fixed pattern, variations of which result in congenital malformations of this portion of the intestinal tract.

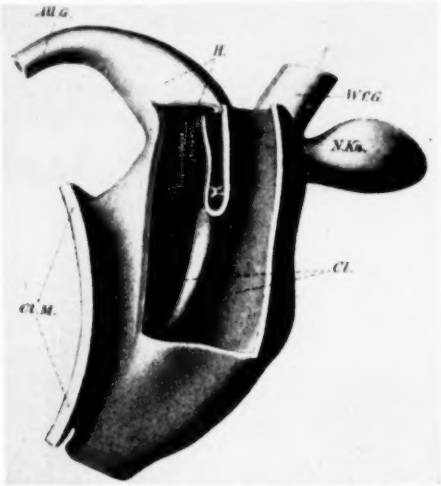

Fig. 1.—Keibel's model [4] of the cloacal region of a 6.5-mm. human embryo (6 weeks) showing an early stage of the partitioning of the cloaca into its two major subdivisions, the urogenital sinus (anterior) and rectum (posterior). *X*, site of the urorectal septum; *All. G.*, allantoic duct; *Cl.*, cloaca; *Cl. M.*, cloacal membrane; *D*, intestine; *H*, bladder; *N. Kn.*, kidney bud; *Wf. G.*, Wolffian duct.

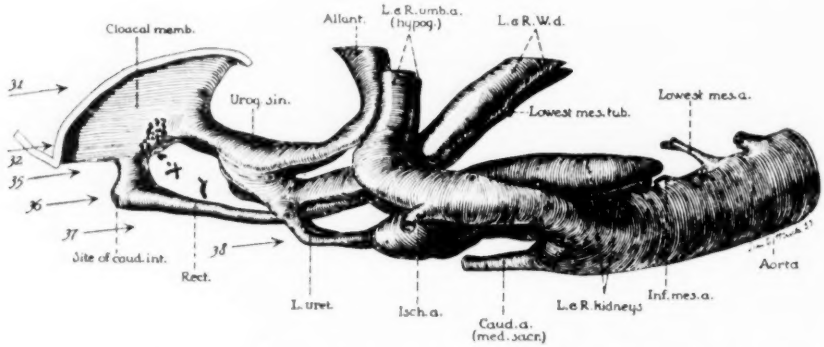

Fig. 2.—Boyden's model (Boyden, E. A.: A Laboratory Atlas of the 13-mm. Pig Embryo, Philadelphia, Westar Institute of Anatomy and Biology, 1933, p. 84) of the cloacal region of a 13.5-mm. pig embryo (stage like that of a human embryo of 7 weeks). *X*, site of the cloacal duct (temporary communication between the urogenital sinus and the rectum); *Y*, site of the urorectal septum.

In embryos of the fifth week the rectum and bladder have not yet developed. Instead there is an embryonic cloaca, as illustrated by Keibel's [4] model of the

4. Keibel, F.: Zur Entwickelungsgeschichte des menschlichen Urogenitalapparates, Arch. Anat. 1896, p. 156.

cloacal region of a 3-mm. embryo. Below the cloacal membrane is a small tailgut, which later disappears. Above the cloacal membrane is the allantois, and the latter structure extends into the body stalk.

In the six-week embryo the urorectal septum is beginning to grow downward to separate the cloaca into the urogenital sinus and rectum (Fig. 1). By further downgrowth of this connective-tissue septum, the connection between the urogenital sinus and the intestinal tract becomes reduced to a slender passage called the cloacal duct (Fig. 2). Finally, at the end of the seventh week, the walls of the cloacal duct coalesce, and the communication between the intestine and the urogenital sinus becomes obliterated.

The connective tissue between the rectum and the urogenital sinus where it reaches the ectoderm constitutes the primitive perineum. At this stage of development the cloacal membrane is divided into urogenital and anal portions, respectively, and by the eighth week the urogenital membrane is absorbed to establish an external opening. In the region of the future anus an invagination develops which is known as the proctodeum. Normally, the anal membrane ruptures during the eighth week to establish continuity between the proctodeum and the anus. Any failure of the anal membrane to break down results in an imperforate anus.

The anal sphincters are derived from regional mesenchyme. Hence anomalies of the epithelial portion of the hindgut would not necessarily involve the sphincters, and so we might well expect to find the sphincter mechanism present in a large percentage of these malformations.

CLASSIFICATION

Many forms of classification have been advanced to cover the various malformations of the anus and rectum. Bodenhamer in 1860 was the first to propose a systematic classification of anomalies in this area. Subsequent classifications have been made by the following workers: Ball [5] in 1887; Keith [6] in 1908; Fraser [7] in 1926; Fitchet [8] in 1926; Ladd and Gross [9] in 1934; Bacon [10] in 1938, and Crowell and Dulin [11] in 1940.

Considerable confusion has existed in the nomenclature of these anomalies until recently, when the simplified system of Ladd and Gross [12] was presented. Most writers have adopted this system in reporting cases. It is certainly not our intention to propose a new method of classification to add to the already existing

5. Ball, C.: The Rectum and Anus: Their Diseases and Treatment, London, Cassell & Company, 1887.

6. Keith, A.: Malformations of the Hindend of the Body, Brit. M. J. **2**:1736, 1908.

7. Fraser, J.: Surgery of Childhood, New York, William Wood & Company, 1926, Vol. 2.

8. Fitchet, S. M.: Imperforate Anus: Surgical Treatment of Cases of Maldevelopment of Terminal Bowel and Anus, Boston M. & S. J. **195**:25, 1926.

9. Ladd, W. E., and Gross, R. E.: Congenital Malformations of the Anus and Rectum: Report of 162 Cases, Am. J. Surg. **23**:167, 1934.

10. Bacon, H. E.: Anus, Rectum and Sigmoid Colon: Diagnosis and Treatment, Philadelphia, J. B. Lippincott Company, 1949, Chap. 3.

11. Crowell, E. A., and Dulin, J. W.: Congenital Anomalies of the Anus and Rectum, Surgery **7**:529, 1940.

12. Ladd, W. E., and Gross, R. E.: Abdominal Surgery of Infancy and Childhood, Philadelphia, W. B. Saunders Company, 1947.

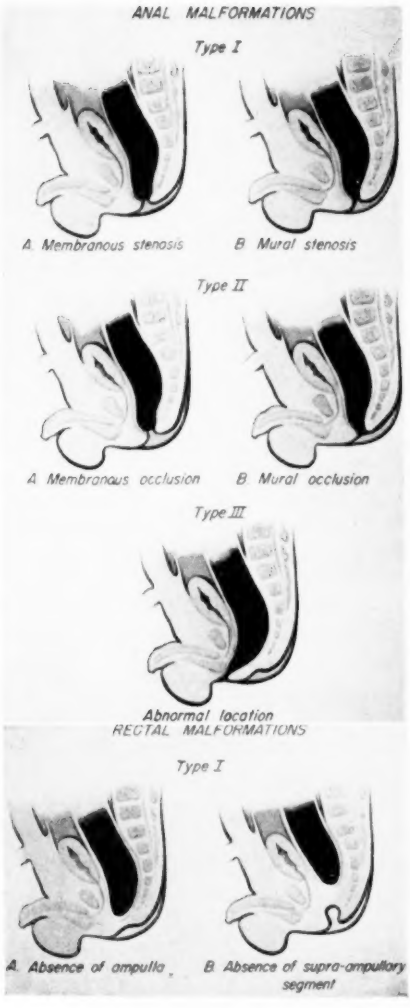

Fig. 3.—Congenital malformations, anal and rectal.

confusion but rather to recommend the use of the least complicated, yet most descriptive, means of classifying these anomalies. We should like to present the following simplified version:

Congenital Malformations

Anal

I. Stenosis of canal
   A. Membranous
   B. Mural
II. Absence of orifice (imperforate anus)
   A. Membranous occlusion
   B. Mural occlusion
III. Abnormal location

Rectal

I. Nonfistulous
   A. Absence of ampulla
   B. Absence of supra-ampullary segment
II. Fistulous
   A. Rectovesical
   B. Rectourethral
   C. Rectovaginal
   D. Rectoperineal

EMBRYOLOGY OF MALFORMATIONS

Anal anomalies of Types I and II occur because of improper absorption of the anal plate during the eighth fetal week. It would seem logical to accept this thesis for the explanation of membranous stenosis of the anal canal as well as of instances of completely imperforate anus. But it is more difficult to understand the pathogenesis of mural or fibrous stenosis of the anal canal unless one is willing to accept Keibel's statement that invasion of the anal membrane with connective tissue takes place and improper absorption of the latter may occur.

Type III anal anomalies occur with underdevelopment or overdevelopment of the urorectal septum. The usual malformation is that of anterior malposition of the anal canal, and this occurs when the perineal body is inadequately formed by the continued downgrowth of the urorectal septum.

Type I rectal malformations can be most logically explained by the assumption that a persistence of the solid stage of either the ampulla or the supra-ampullary portion of the rectum has occurred. Keibel observed an obliteration of the lumen of the rectum in an 11.5-cm. embryo. Lewis and Minot [13] confirmed similar observations in pig, rabbit and bird embryos. It has been suggested that its function is to prevent the passage of the excretion of the Wolffian bodies into the intestine. After the cloacal duct is obliterated, this impediment is no longer present and the lumen of the gut reappears. This embryological explanation of Type I rectal malformations would seem to be more reasonable than the postulation that the rectum is destroyed by a resorptive process, as has been shown to occur in the tailgut of the ostrich embryo.

Type II rectal malformations (fistulous) usually occur in conjunction with the Type I A anomalies (absence of ampullary segment), but they have been reported with anal malformations as well. Whether the incomplete downward extension of the mesenchymal urorectal septum or a primary failure of the cloacal duct to disappear is responsible for anomalous connections between the rectum and the genitourinary tract in the male has not been definitely established. Both explanations have their advocates; however, we favor the latter.

13. Cited by Keibel, F., and Mall, F. P., editors: Human Embryology, written by C. R. Barden and others, Philadelphia, J. B. Lippincott Company, 1912, p. 325.

In a female fetus connections between the rectum and the genital tract are undoubtedly formed during the descent of the region of attachment of the Müllerian ducts to the posterior wall of the urogenital sinus; the ducts assume any fistulas already existing between the rectum and the urogenital sinus. Such fistulas may connect the rectum with the vagina or the uterus; the latter anomaly is rare. Rectoperineal fistulas are probably formed by obliteration by the anterior or ventral portion of the cloacal duct, with persistence of the dorsal portion; dissolution of the cloacal membrane results in an external perineal opening.[14]

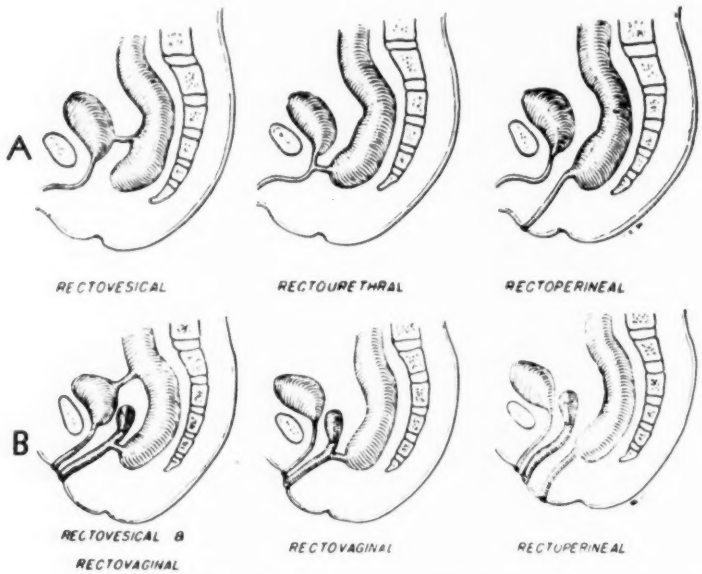

Fig. 4.—*A*, diagram of types of fistulas most commonly found in males with rectal malformations. *B*, diagram of types of fistulas most commonly found in females with rectal malformations. (Ladd and Gross.[12])

INCIDENCE

The incidence of congenital anomalies of the anus and rectum is variously reported as 1 in 5,000 to 1 in 10,000 childbirths. These malformations occur somewhat more frequently in males than in females. It is unusual to have similar anomalies in siblings, yet their occurrence has been reported.

Sex Incidence (Authors' Cases)

Males	63
Females	48
	111

ASSOCIATED ANOMALIES

Congenital malformations of the anus and rectum are commonly associated with congenital anomalies elsewhere in the body. Associated anomalies have been variously reported to occur in 18 to 68% of the patients studied. In our group of 111 patients 32, or 29%, had detectable associated anomalies.

14. Lemon J. Wells, Ph.D., Professor of Anatomy, University of Minnesota, collaborated in preparing the section on embryology.

The mortality among patients with congenital anomalies of the anus and rectum is considerable and may result more from the associated congenital deformities than from surgical therapy.

DIAGNOSIS

Most anal malformations can be readily detected by careful inspection of the perineum at birth. Instances of totally imperforate anus are obvious if this area is examined. Meconium may be observed distending the persistent anal plate in some cases. In others, palpation of the rather thin anal membrane may give a sensation of resiliency and one may well suspect that the rectal pouch is located slightly cephalad. However, one may have to resort to x-ray examination in order to ascertain the true location of the terminal bowel. If this malformation is not detected by physical examination and treatment instituted, signs of bowel obstruction will soon become manifest.

TABLE 1.—*Associated Congenital Anomalies (Authors' Series)*

Anomaly	No. of Cases
Harelip and cleft palate	2
Meckel's diverticulum	2
Polycystic kidney	1
Exstrophy of bladder	3
Hypospadias	4
Omphalocele	1
Undescended testes	2
Spina bifida	2
Meningocele	2
Pyloric stenosis	2
Hirschsprung's disease	2
Club feet	1
Syndactylism	2
Supernumerary digits	2
Double vagina	1
Atresia of vagina	1
Imperforate hymen	2
Total	32

The diagnosis of membranous or fibrous stenosis of the anal canal may not be apparent for some time after birth and then only when signs of obstipation or even obstruction develop. A careful digital and anoscopic examination with a stricturoscope will usually reveal the condition. Fistulas occurring with anal malformations may be detected by inspection, probing, or the injection of a radiopaque substance. In the male, rectoperineal fistulas are manifest as a dimple at the median raphe and may be located in the perineum or the scrotum. Most fistulas associated with anal anomalies call attention to their presence by the passage of stool or flatus. Abnormal location of the anus is usually not discovered until some time after birth. In the female, fecal contamination of the vagina is the usual signal.

Accurate determination of the exact nature of rectal malformations is frequently not easy, and the examiner may have to resort to several methods to clarify the existing pathologic process. In Group I A, anomalies with absence of the ampullary segment, it is obvious that the patient has an imperforate anus but the level of the rectal pouch and the amount of intervening tissue is the point in question. Palpation of the anal area will frequently be enough to convince the examiner that he is dealing with a greater barrier than is encountered with persistence of the anal plate.

Wangensteen and Rice [15] proposed the "inversion x-ray" examination of newborn infants with congenital anal and rectal anomalies to determine the amount of intervening tissue. A radiopaque marker is placed over the anal dimple, and exposures are made with the child in the inverted position. Several observers have doubted the accuracy of this method for infants younger than 24 hours of age, since they feel that swallowed air has not had time to reach the sigmoid and rectum. Paine,[16] however, demonstrated that the rectum and the sigmoid colon were filled with air in a series of normal newborn infants as early as six hours after birth. We have used this method of examination routinely for all patients with imperforate anus and absent rectal segments regardless of their age and have found it most useful. However, most of our patients were seen when they were 24 hours of age or older. When air is not present in the terminal bowel, gentle abdominal massage with the infant in an inverted position may induce it to reach to the rectal pouch.

Since approximately 35% of patients with absent ampullary segments have fistulas, we have found that the instillation of a radiopaque liquid, such as iodopyracet injection (35% diodrast®), through the fistulous tract is of value not only in visualizing the fistula but also in determining the level of the rectal pouch. Rectovaginal and rectoperineal tracts are usually easily filled with radiopaque substances. Rectourethral and rectovesical tracts are more difficult to fill, but filling can usually be accomplished with a small catheter in the urethra or the bladder.

Our experience with Type I B anomalies (absence of supra-ampullary segment) has not been extensive, and we suspect that the diagnosis is difficult in many instances until signs of bowel obstruction are apparent. At that time digital and proctoscopic examination of the anal canal and distal rectum should confirm the existence of a blind distal pouch. "Inversion x-ray" examination of the infant with an opaque marker in the distal pouch should confirm the absence of the rectal segment and the location of the proximal pouch. Fistulas are reported to occur infrequently with this type of anomaly, and so an attempt to locate the proximal rectal pouch by dye injection of fistulous tracts is not very helpful.

When infants have been subjected to colostomy as an emergency measure in treating congenital anomalies, it is advisable to fill the distal colostomy limb with a radiopaque substance and make x-ray exposure from several positions to gain a more clear-cut impression of the exact nature of the anomaly, before definite surgery is attempted. With these patients, the "inversion x-ray" examination should also be carried out and the genitourinary tract thoroughly examined for possible fistulous connections.

TREATMENT

If the nature of the anomaly in the newborn infant is such that no vent is provided for the egress of flatus or feces from the intestinal tract, signs of bowel obstruction will soon become apparent and some type of decompressionary procedure will be mandatory. When stenoses or fairly large fistulas exist, diversionary procedures may not be necessary and definite surgery may be postponed until a later date. However, each case must be evaluated individually.

15. Wangensteen, O. H., and Rice, C. O.: Imperforate Anus: Method of Determining Surgical Approach, Ann. Surg. **92**:77, 1930.

16. Paine, J. R., and Nessa, C. B.: Observations on Distribution and Transport of Gas in the Gastrointestinal Tract of Infants and Young Children, Surgery **11**:282, 1942.

Anal anomalies, including the occasional associated fistulas, may all usually be corrected by perineal operative procedures. Type I anal malformations can usually be handled simply. When a partially persistent anal membrane occurs, it may be excised completely or incised and the free margin attached with sutures to the sphincter ani muscle fibers. It is frequently advisable to perform a posterior sphincterotomy, i. e., incise the sphincter muscle bundle to some degree in the posterior commissure, if any residual stenosis exists. Mural stenosis of the anal canal is usually most successfully treated by the performance of some type of anoplasty. We prefer the Martin type of anoplasty whereby the anal outlet is enlarged by a posterior sphincterotomy and a V of mucosa is lightly sutured to the sphincter muscle fibers at the posterior commissure. These are all relatively minor operative procedures that give the patients much better ultimate results than simple incision and repeated dilatations, so frequently advised in the past for anal anomalies.

TABLE 2.—*Anal Malformations: Incidence, Treatment, and Results*

Congenital Anomaly	No. of Cases	Procedure	Cured	Improved	Unimproved	Postoperative Deaths
I. Stenosis of canal						
A. Membranous	17	15 Incision and dilatation 2 Anoplasty	17	..	..	0
B. Mural	5	5 Anoplasty	3	1	..	1
II. Absence of orifice (imperforate anus)						
A. Membranous occlusion	8	8 Incision and dilatation and sphincterotomy	7	..	..	1
B. Mural or fibrous occlusion	14	3 Died on admission; no surgery 11 Incision or excision with plastic procedure	9	1	..	1
III. Abnormal location	3	2 Modified Rizzoli 1 Not operated on	2	..	1	0
Total.....	47		38	2	1	3

Completely imperforate anal plates may be incised with cruciate incisions and the skin edges trimmed, or the tip of each quadrant may be lightly sutured to the sphincter muscle.

Abnormally located anal canals are usually misplaced anteriorly. A line drawn transversely between the midportion of the ischial tuberosities represents the usual plane in which the normal anal canal is located. The anus and rectum can be transplanted to their normal location by the use of modified Rizzoli procedure (Fig. 5). Unless one constructs an adequate perineum or rectovaginal septum, as the case may be, with levator ani muscle in the performance of this procedure, there is a great tendency for the rectum to resume its malplaced position in later years.

The presence of a congenital rectal malformation in a newborn infant usually merits the prompt institution of some diversionary procedure, such as a colostomy. Occasionally the fistulous tracts that frequently occur with these anomalies are large enough to prevent bowel obstruction, but this is usually not the case except with some of the rectovaginal fistulas.

Prior to the past decade, Types I and II rectal anomalies were usually treated by some type of proctoplasty, and the results in many instances were far from good. Poor results were obtained for several reasons: 1. When the rectal pouch was high,

adequate mobilization could not be obtained and the rectum could not be pulled down to the anal sphincter without undue tension, so sloughs were frequent and fibrous and stenotic outlets resulted. 2. Attempts to suture the bowel to the sphincter were not always successful because the bowel retracted, and here again fibrous, stenotic outlets resulted. 3. High fistulas (rectovesical and rectourethral) can be more easily isolated and more adequately treated by means of a combined abdominoperineal approach than by the use of a purely perineal procedure. 4. There is considerable danger of breaking through the pelvic peritoneum and spreading fecal contamination to the peritoneal cavity when a high rectal pouch exists.

During the past decade the combined abdominoperineal approach to Types I and II rectal malformations has gained many supporters. Rhoads has advocated a simultaneous abdominal and perineal procedure to be performed by two operating teams as a solution for these malformations. Norris and his associates [17] feel that Types I and II rectal anomalies can be best handled by performing a primary abdominoperineal procedure on newborn infants early, before signs of bowel obstruction become marked. They reported on nine infants thus treated, with a 9.1% mortality rate.

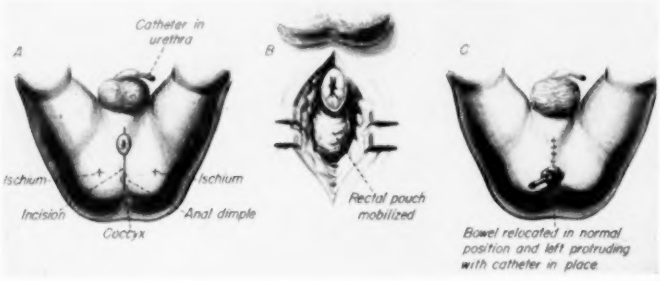

Fig. 5.—Demonstration of modified Rizzoli procedure.

It is our feeling that a procedure of this magnitude exposes the newborn infant, with an already existing bowel obstruction, to a greater degree of trauma than is warranted at this stage of life, and particularly when a fistulous tract is encountered its dissection would surely consume more valuable time. When it has been ascertained that the newborn infant has a fairly high rectal pouch that cannot be easily mobilized from the perineum and signs of bowel obstruction are apparent, it has been our policy to perform a transverse colostomy as soon as possible. We have in the past usually postponed the definitive reconstructive operative procedure until the child is at least 3 years old. In some instances abdominoperineal procedures have been performed earlier when the pediatrician has felt that the infant represented a good operative risk. We should like to advise against exteriorizing the sigmoid colon as a colostomy in these cases as it usually limits mobility of that segment of bowel for subsequent "pull-through" procedures.

In our group of 111 patients, 64 infants had rectal anomalies. Of this group (64) of patients with rectal malformations, 40 (62.5%) presented associated fis-

17. Norris, W. J.; Brophy, T. W., and Brayton, D.: Imperforate Anus: A Case Series and Preliminary Report on the One Stage Abdominoperineal Operation, Surg., Gynec. & Obst. **88**:623, 1949.

tulas and 29 of these fistulas were rectovaginal. Thus 45.3% of the entire group with rectal malformations and 72.5% of the group (40) with associated fistula were found to have congenital fistulous tracts between the rectum and the vagina (Table 3).

It has been our experience that the operative procedure as devised by Rizzoli,[18] with some modifications, has proved to be the most satisfactory method of treating Type I B rectal malformations with rectovaginal fistulas (Fig. 6). As was pointed out previously, there are a number of objections to the perineal repair of these malformations, but it is our feeling that we can obtain more extensive mobilization

TABLE 3.—*Rectal Malformations: Incidence, Treatment, and Results*

Congenital Anomaly	No. of Cases	Procedure	Cured	Improved	Unimproved	Postoperative Deaths
I. Nonfistulous						
A. Absence of ampulla	20	10 Proctoplasty	6	2	..	2
		1 Unsuccessful perineal attempt followed by colostomy	..	..	..	1
		8 Colostomy alone	..	..	8	0
		5 Colostomy followed by proctoplasty	4	1	..	0
		1 Colostomy followed by APPS* at 4 years	1	..	..	0
B. Absence of supra-ampullary segment with anal canal and lower segment present	4	3 Colostomy	..	..	3	0
		1 Proctoplasty	..	..	..	1
II. Fistulous						
A. Rectovesical	3	2 Colostomy, suprapubic cystotomy and perineal repair	..	2	..	0
		1 Colostomy and APPS*	1	..	..	0
B. Rectourethral	6	3 Colostomy and suprapubic cystotomy followed by repair	..	3	..	0
		2 Colostomy followed by APPS*	2	..	..	0
		1 Colostomy	..	1	..	0
C. Rectovaginal or rectovulvar	29	29 Rizzoli procedure 3 temporary colostomy 1 permanent colostomy	25	2	2	0
D. Rectoperineal	2	2 Perineal repair	1	1	..	0
Total:						
Rectal	64		40	12	8	4
Anal	47		38	2	1	3
	111		78	14	9	7

* Abdominoperineal proctosigmoidectomy, or "pull-through" procedure.

of the rectal segment with this procedure than with any of the several other methods of proctoplasty that have been suggested. When possible, we like to exteriorize the fistulous tract and a small portion of the distal rectum over a large mushroom catheter to compensate for the anticipated retraction that frequently results, rather than suture the rectal mucosa to the skin margins primarily. Usually the redundant bowel can be excised and the anal canal reconstructed as a minor operative procedure seven to eight days after the initial surgery. If one reconstructs the perineal body carefully during this procedure the likelihood of anterior recession of the rectum is minimal.

18. Rizzoli, F.: A New Operative Method Executed in 4 Cases of Congenital Atresia Ani with Opening of the Rectum into Vulva, Surg. Mem. **2**:321, 1869.

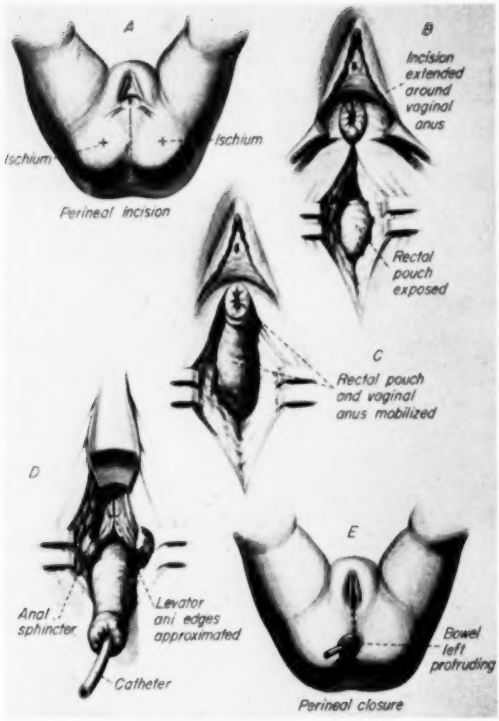

Fig. 6.—Method of treatment of rectal malformations with rectovaginal fistulas.

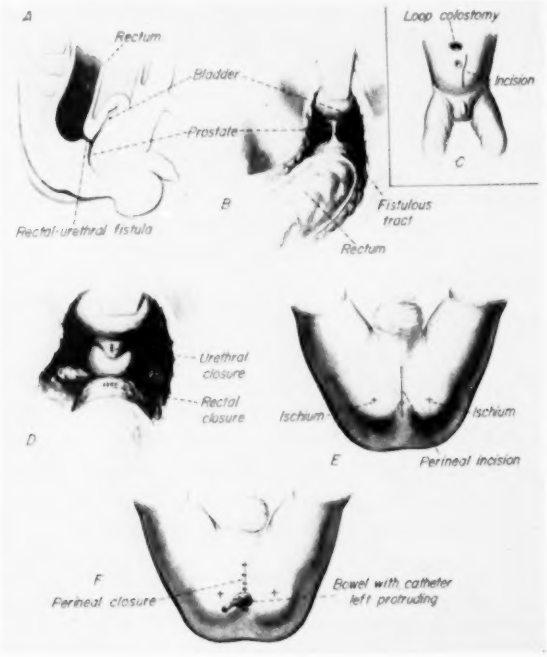

Fig. 7.—Abdominoperineal proctosigmoidectomy procedure, with preservation of the anal sphincter muscle, for treatment of malformations.

We now prefer to reconstruct the remaining rectal malformations with an abdominoperineal operative procedure when the patient is 3 to 5 years of age. The abdominoperineal proctosigmoidectomy or "pull-through" procedure with the preservation of the anal sphincter muscle bundle as we have adapted it for the treatment of congenital malformations is similar to the procedure that has been previously described for the resection of carcinoma of the proximal rectum and distal sigmoid colon, except that it is less radical (Fig. 7).

SUMMARY

Imperfections in the normal developmental pattern of the anus and rectum are responsible for the congenital malformations that occur in this area. These developmental defects occur during the sixth to ninth week of fetal life.

A more complete system of classification of these anomalies is suggested, and an embryologic explanation is offered for the various types of malformations.

The incidence of congenital malformations of the anus and rectum is estimated to be 1 in 5,000 to 10,000 births. Twenty-nine per cent of our group of 111 patients had associated congenital anomalies elsewhere in the body.

The diagnosis of anal stenosis and imperforate anus, per se, is not difficult; but confirmation of the absence of an ampullary or supra-ampullary segment of the rectum, with the frequently associated fistulas in the former, is more difficult. The diagnosis of rectal malformations is discussed in some detail.

Anal malformations can usually be corrected easily by the use of relatively minor perineal operative procedures. The end-results are generally much better than those obtained with the classical incision and dilatation procedure. Rectal malformations, except for rectovaginal fistulas, are best corrected by a combined abdominoperineal operative procedure. We prefer to perform the definitive procedures when the child is 3 to 5 years of age. Our operative mortality rate for the 108 patients treated surgically was 6.4%.

ABSTRACT OF DISCUSSION

DR. MONTE EDWARDS, Baltimore: Drs. Bacon and Sherman have shown us only too clearly what can be accomplished by a more vigorous approach to a small branch of surgery which in many centers has had rather perfunctory handling. It is to their credit that they have been able to point the way to better results in a field lagging somewhat by present-day standards. Considering the infrequency of these anomalies, Drs. Bacon and Sherman are fortunate in having had such wide experience, and in that probably lies one of the factors in their success. Here is demonstrated what can be done with concentration of effort, which in most institutions is scattered over too many services and with no uniformity of management.

The pattern for the treatment of these cases includes the alertness of the newborn's first attendants, the assistance of the pediatrician in nutritional problems, and a recognition by the surgeon of the most favorable time for operative intervention, whether this is to be a curative measure or something palliative with a view to restoration of function at a later date.

Technically there is need for some delicacy in avoiding unnecessary trauma to membranes which are of tissue-paper thickness and for instruments and suture material to correspond.

I question, not too vehemently, the necessity for yet another classification on the grounds that any further shading is unlikely to clarify either developmental origin or surgical approach. That of Ladd and Gross may be considered an oversimplification, but it has the virture of few categories and the inclusion of all but the rarest states.

Coexisting anomalies have in my limited experience been a rather more formidable feature than they have been represented here, and, in addition, diarrheal disorders have at times posed a serious problem.

I consider the essayists' contribution an important one in that it brings a note of optimism into a field of endeavor which heretofore has been none too productive of good results.

Dr. Mark M. Ravitch, Baltimore: Dr. Bacon has observed a large and impressive series, with excellent results. I should like to emphasize several of the points which he made.

From the standpoint of the treatment with diversionary colostomy, the use of a transverse colostomy instead of a sigmoid colostomy will frequently avoid embarrassment later on when it becomes necessary to mobilize the bowel and bring it down. Anorectal anomalies are not among the congenital malformations of the newborn that require instant operation. I know of only one or two that are. Large omphaloceles are one, and another is a strangulated diaphragmatic hernia. A period of several hours, sometimes 18 to 24 hours, elapses before the child is likely to be at all distressed, and during this period there is plenty of time to prepare the patient for operation and, if necessary, to transport him to a clinic in which adequate pediatric and surgical care is available.

I agree with Dr. Edwards that associated anomalies are serious and important. Certainly, in cases of tracheoesophageal fistulas one of the commonest associated anomalies is anorectal malformation.

We have been inclined to favor, with Dr. Norris and his group in Los Angeles and Dr. Rhoads in Philadelphia, the immediate combined abdominoperineal approach to the complicated anomalies immediately after birth. The child can readily be draped by putting circular towels completely around the epigastrium, and draping the entire lower half of the body free. The small body can easily be manipulated back and forth for the combined abdominoperineal approach. It has the great merit that with the complicated anomalies, with rectourethral fistulas, or with a high-lying rectal pouch, it is possible to do the bulk of the dissection from above. There is no particular difficulty, either in dividing the ordinary rectourethral fistula from above. It is usually just beyond the prostate and in an infant can be reached readily from above.

What is required then is not an extensive dissection through the perineum but merely a probing through in the midline from above and from below, right through the center of the sphincter without much distortion of structures. We then suture the rectal mucosa directly to the skin with fine sutures, and the technique in general should be emphasized as being a delicate plastic procedure.

In the primary perineal operations we use plastic scissors, mosquito forceps, and arterial silk; I prefer not to divide the sphincter posteriorly or anteriorly because a slower and more painstaking dissection may produce in the end a better sphincter.

Finally, at least as important as the operation itself is the care of the wound after operation, with careful dilation for as long as necessary to avoid stricture formation.

PRINCIPLES OF INTERNAL FIXATION WITH PLATES AND SCREWS

LEONARD T. PETERSON, M.D.
WASHINGTON, D. C.

IN THE open treatment of fractures, plates and screws are the devices most commonly used for internal fixation. The successful use of this method of fixation depends on fundamental mechanical principles which will be reviewed in this discussion. The indications, surgical technique, and postoperative care will not be considered at this time. The relative merits of other methods of fixation will also be omitted except to say that wire, pins, intramedullary devices, and bone grafts have their proper place, and in many instances the use of one or more of these is the method of choice.

Failures of internal fixation, which are far too common, are often attributed to factors such as metal, electrolysis, absorption, or pressure necrosis. These terms are often meaningless or incorrect as explanations for failures, which can be attributed to more obvious and direct causes. The fault usually can be found in defective materials or in improper technique of application.

MATERIALS

Two metals, stainless steel of the type commonly referred to as 18-8 SMo and vitallium, have met the requirements of being inert and otherwise suitable for use in the body. While detailed specifications for manufacture and inspection have not been universally adopted, those used by the armed forces represent the latest developments and provide the basis for a future federal specification. There is urgent need for standardization, and some method of supervision by the profession, of all devices and prostheses to be left in the body. Until this is attained, the surgeons must individually and collectively require of the manfacturers the highest standards of material and design.

The metal should be of constant composition and hardness. The steel which has been referred to above hardens as it is fabricated (work hardens) and therefore must not be heated to facilitate manufacturing. This heating has been common practice by one or more manufacturers, and the resulting products are too soft and weak.

The holding power of screws depends on the quality of the threads cut in the bone. These bone threads are cut by the screw and furnish the entire support for the screw threads which oppose them. Any factor which decreases the depth of the bone threads or which damages the bone decreases the holding power accordingly. This fundamental principle is so often neglected that its importance must be reemphasized.

Read before the Section on Orthopedic Surgery at the One-Hundredth Annual Session of the American Medical Association, Atlantic City, June 15, 1951.

Fig. 1.—Cross section of bone illustrating threads properly cut by a good screw. Excellent holding power may be expected.

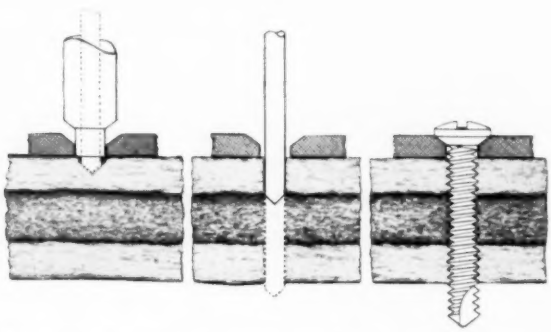

Fig. 2.—A drill guide is essential for proper centering of the drill point in relation to the hole in the plate. After the drill has been started, the guide is removed. The screw head fits the countersink of the plate, and threads are not damaged.

Disproportion between drill size and screw diameter is one of the most serious errors, since too large a drill hole leaves insufficient bone engaging the screw. Too small a drill necessitates excessive pressure for insertion of the screw, with the danger of breaking the screw or damaging the bone. Therefore, it is imperative that the drills be of constant diameter in relation to the screws, and this means that

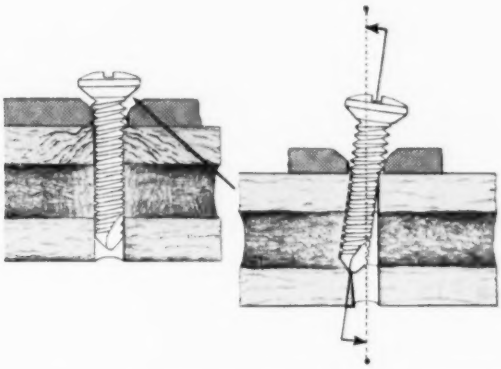

Fig. 3.—If the screw is placed eccentrically (figure on left) or angulated (figure on right), the metal threads are damaged by contact with the plate. Furthermore, as the head of the screw is drawn into the countersink, lateral migration occurs, with further damage to the bone threads already cut.

Fig. 4.—*A*, the undamaged threads of this screw will accurately fit the bone threads illustrated in Figure 1 and produce the maximum holding power. *B*, a similar screw after the threads have been damaged by the plate due to angulation and eccentric position as in Figure 3. The bone threads cut by this screw will be defective, and the screw will have poor contact and limited holding power. A drill guide would have prevented this error. (Acc. 219564, Armed Forces Institute of Pathology.)

there is only one optimum drill size. A drill diameter of 0.110 in. (2.79 mm.) (No. 35 drill) is specified for a screw with a major diameter of 0.138 in. (3.50 mm.) and a root diameter of 0.097 in. (2.46 mm.). Thus, the screw engages bone to a depth

of only 0.014 in. (0.35 mm.) $\frac{0.138-0.110}{2}$ at any point. In my opinion, the disproportion between the size of drills and screws is the commonest cause of failure of internal fixation. Unfortunately, in some hospitals screws and drills made by

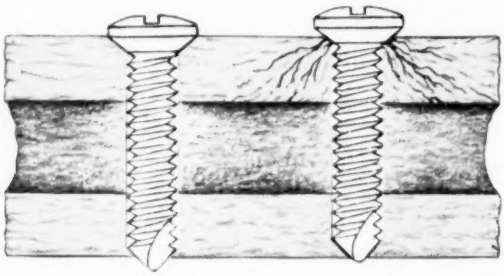

Fig. 5.—When screws alone are used to transfix fragments, the bone should be countersunk to fit the screw head. Failure to observe this detail leaves the head protruding or causes the bone to split.

Fig. 6.—This case of nonunion of the femur illustrates several technical errors in internal fixation. The material included a plate of one metal and screws of another. The two broken drill points were of different size. The screws had not been tightened uniformly. The lower screws underwent fatigue failure, due to motion.

various manufacturers are frequently mixed and selection is haphazard. Since the correct diameter depends on tolerances of a few thousandths of an inch, it is important that the exact dimension of screws and drills be known to the operating sur-

Fig. 7.—Screws properly centered and perpendicular to the plate give the best fixation. Note the angulation of screws 2, 5, and 6, with poor contact between screw and plate. Loosening is probably due to oversized drill holes, resulting in shallow bone threads and diminished holding power.

Fig. 8.—The screws were not uniformly tight, resulting in slight motion and nonunion of the tibia. One year after fixation, angulation occurred. Two screws suffered fatigue failure and could not be removed. A sliding bone graft fixed with four screws resulted in union.

geon. This knowledge is as important as the exact milligram dosage of a potent drug in the administration of which error of a few milligrams might mean disaster. An error of a few thousandths of an inch in the size of drills or screws will result in failure of fixation, with its well-known consequences such as nonunion, deformity, reoperation, disability, and severe economic loss.

Only unbreakable drill points such as those made of 18-8 SMo steel should be used. These become dull more readily than the usual commercial drill points, but they should be considered expendable and discarded when unserviceable. A broken drill point results in loss of a screw hole, often precluding the use of a vitally

Fig. 9.—Nonunion of the tibia is due to fixed distraction and motion. The lower three screws were inserted at the wrong end of the slots, thereby preventing impaction of the fragments. The extra screw also prevented impaction. The plate was poorly centered, so that one screw entered the fracture line, leaving only one screw firmly fixed in the lower fragment.

important screw. A broken drill leaves an incompatible metal in the bone, and its removal may be extremely difficult.

Screws should have flutes of good cutting quality, so that the bone threads are cut sharply. The metal threads must be uniform and cleansed of all debris, since defective threads will damage the bone already tapped. The relative merits of fine and coarse thread screws have not been established, but either type is satisfactory if other criteria are met. The threads should extend to the head of the screw, and the taper of the head should be constant and slightly greater than the countersink of the hole in the plate. For ease of insertion and removal, the cruciate and Philips head screw are superior to the conventional slotted head screws.

The plate which is used to fix the fragments of any fracture must obviously have adequate size and strength for the occasion. Strength is especially important at the fracture site, usually the midportion of the plate, and is proportionate to the dimensions of the plate. In the femur, tibia, and humerus, six-screw plates are indicated, and it is believed that three screws in each fragment provide as much rigidity as the plate which they fix. Curved plates are preferable to flat plates, and the radius of curvature should be less than the radius of the bone. Thus, the plate engages firmly at the edges, and rocking motion is prevented. The latter motion promotes loosening and fatigue failure of the screws. Catenoid plates are designed to have uniform strength, with the minimum amount of metal, but they probably have no merit over straight plates, except where they are more easily fitted to the smaller bones. The recently developed slotted plates possess advantages over conventional round-hole plates, since they allow variation of screw location and impaction can be produced both during and after fixation. In either type of plate the countersink of the hole or slot should correspond to the head of the screw.

TECHNIQUE

After satisfactory reduction of the fragments has been accomplished, if the plate does not fit uniformly it should be bent to the correct contour. The screws should not be used to bend the plate after it has been applied, since this will result in unequal tension on the screws and predispose to breakage. When a large separate fragment of bone is present, it is often desirable to reduce and fix it with one or more screws before approximating the major fragments. Distraction should be avoided, especially in transverse fractures, and impaction should be produced before fixation, unless slotted plates are used when impaction can be obtained after all screws have been inserted but before they are tightened.

Each screw should be properly centered in the hole or slot in order to avoid damage to the flutes and threads of the screw as it is inserted and in order to make the screw head fit the countersink in the plate. The quality of fixation depends on the contact between the screw head and the plate, except in instances in which the screw engages two fragments of bone. A drill guide is essential for the proper centering of the drill point and therefore of the screw. The guide should be used only to start the hole and should then be removed, after which the drill is reinserted without the guide. Failure to remove the guide often causes the drill and guide to become bonded together, especially if drilling is done rapidly. Speed should not be excessive so that the bone is overheated and thereby fragmented when the threads are cut. The drill must be held firmly to avoid wobble and enlargement of the hole.

When screws are used without a plate, the drill hole should be countersunk with the use of a countersink which has the same angle as the head of the screw. This makes the screw fit the bone, avoids the danger of splitting the bone by the tapered head, and makes the screw less prominent.

After all the screws have been inserted, they should be tightened repeatedly to the same degree, in order to prevent unequal pressure, which might cause each screw to break in turn.

One disadvantage of plate fixation has been the fixed distraction which has often resulted, especially in old fractures, where fragments fit less accurately than in fresh

Figure 10

(See legends on opposite page)

fractures. Since impaction promotes union, it is desirable to impact the fragments at operation if possible and also to stimulate impaction by muscle pull or weight bearing. Slotted plates fulfill these requirements and may be used for relatively firm fixation or may be applied loosely, as advocated by Eggers.[1] Complete immobilization can be obtained along with physiological impaction by the use of two slotted plates. The latter method of fixation permits immediate weight bearing without any support, even in severe fractures of the femur.[2]

ABSTRACT OF DISCUSSION

DR. FRANCIS W. GLENN, Miami, Florida: What bothers most of us in using screws and plates is the fact that too many of them fail. It is rather simple, mechanically, to judge the size of the plate or the screws which we are supposed to use, but there is a human element in drilling a hole, which is difficult to do perfectly, even with the drill guide. The disproportion between the drill and the screw is probably the commonest error, or one of the commonest. The simplest way is to have three drill points at least, all of the same size and made especially for the screws that you have in your set.

Another simple method would be to use a device such as mechanics use to cut the threads, in other words, to have a drill and a die so that your threads will fit perfectly. The question of whether fine threads or coarse threads are better has never been satisfactorily settled.

I question rather strongly the advisability of early weight bearing with the use of two sliding plates or even with two plates at right angles, and I assume that Dr. Peterson meant they were at right angles. Roentgen evidence of union should still be the criteria. It should not be construed that this type of fixation is perfect and without risk. Other factors to be considered are the type of patient, occupation, and economic status. One of the manufacturing companies makes a set which has a 7/64 in. drill for a 9/64 in. screw. The other factor to be considered is the binding of the plates, which will automatically spoil the countersink and the direction of the screw and will often weaken the fixation.

DR. VERNON THOMPSON, Los Angeles: Dr. Peterson has achieved his sharply defined objective, which is to outline the principles of the use of plates and screws from the mechanical and technical point of view.

I should like to emphasize his insistence on using screws with the long axis of the screw at right angle to the plane between the plate and the bone. It is equally important when screws are used to fix two bone fragments that they should be at a right angle to the general plane of the fracture so that displacing forces are exerted in the long axis of the screw. Tension stress on the screw is well withstood, but lateral bending stresses are poorly tolerated.

It is curious that the moment we open fractures we suddenly begin to think in terms of absolute immobilization as the sign that the surgeon is a bone expert. If there is a little wiggle or a little rock, that is the reason the bones did not grow together. The ratio of fractures that are closed and must necessarily wiggle somewhat must be at least a hundred to one, with the

1. Eggers, G. W. N., Internal Contact Splint, J. Bone & Joint Surg. **30-A**:40-51, (Jan.) 1948.

2. Peterson, L. T., and Reeder, O. S. R.: Dual Slotted Plates in Fixation of Fractures of the Femoral Shaft, J. Bone & Joint Surg. **32-A**:532-541 (July) 1950.

EXPLANATION OF FIGURE 10

Fig. 10.—*A*, fracture of the femur before and after fixation with two slotted plates. Unrestricted weight bearing without external fixation one week after operation resulted in early union. The screws which were inserted in the distal ends of the slots have apparently migrated toward the fracture site, indicating impaction of the fragments either during or after operation. *B*, open fracture of the tibia with marked displacement before and after fixation. A slotted plate with screws properly inserted in the distal ends of the slots permitted impaction by early weight bearing in a long cast and resulted in prompt union. Short screws are probably adequate if the bone is normal and the technique correct.

rate of nonunion a lot lower than in those in which the fracture site is opened up and a lot of hardware applied. Dr. Peterson touched on this subject by saying that in the short spiral fracture of the tibia, fixed by two or three screws, a cast would have to be used and at the other end of the spectrum was the femur with the two plates that permitted full weight bearing initially.

The value of the principles outlined in this paper will be enhanced if the reader gives even greater consideration to the physiological principles underlying the general management of fractures. Of course, this is a large subject and is not within the scope of this paper.

DR. E. P. WEIGEL, Plainfield, N. J.: I want to thank Dr. Peterson for a splendid presentation of the mechanical principles involved in internal fixation. One only has to see his slides and know something of his work to realize that a master mechanic is at work. However, I wish to sound a word of caution in reference to the promiscuous operations performed on these fractures. The x-rays shown demonstrate the badly applied plates, poor material used, and poor relationship between screws and plates, and are adequate evidence that inferior mechanical work is being done. We should realize that every time we convert the simple fracture into a compound one by operation, even with the antibiotics which we now have to help us, we complicate the case materially.

Many of these fractures can be treated by closed reduction, careful application of well-fitting plasters, and skeletal traction. We should definitely sound a word of caution about the promiscuous use of metal in the open operations on many of these fractures. In many cases I am sure healing time is prolonged rather than shortened by open operation. Unless open operation can be performed in well-equipped hospitals by highly trained surgeons, the average bad fracture of long bones would be better treated by closed methods. In other words, I feel that the roentgenograms which Dr. Peterson has shown prove that many of the operations have been performed by inexperienced surgeons, and as usual the patient suffers. All patients will not be fortunate enough to have Dr. Peterson correct the mistakes of their first operation.

DR. LEONARD T. PETERSON, Washington, D. C.: I am in complete agreement with everything which the discussors have said, including the precautions which have been stated. Dr. Glenn has emphasized an important point, namely, the availability of drill sizes. The operating room should have only one drill size available for the screws to be used.

Instead of thinking in terms of fractions of an inch, we should revise our terms to cover more accurate measurements. Dr. Blount said yesterday that he believed we should think in terms of millimeters, to be accurate. When it comes to dimensions of screws, we have to use thousandths of an inch. To make a drill size of 0.110, the manufacturing specifications have to allow a slight tolerance such as 0.110 plus or minus 0.001 or 0.003 of an inch. For drill sizes measured in 7/64 or 9/64 in., conversion into tolerances as required in specifications becomes very complicated. It is as important for the orthopedic surgeon to use accurate terms and to know the materials he is using as it is for the internist to measure a potent drug in milligrams.

X-RAY VISUALIZATION OF THE INTERVERTEBRAL DISK

With a Consideration of the Morbidity of Disk Puncture

W. JAMES GARDNER, M.D.
ROBERT E. WISE, M.D.
C. ROBERT HUGHES, M.D.
F. B. O'CONNELL Jr., M.D.
AND
E. C. WEIFORD, M.D.
CLEVELAND

ALTHOUGH the results of surgical treatment of protruded intervertebral disks are better than those when such treatment is not carried out, nevertheless they do leave something to be desired. Therefore, any method of investigation which promises to add to our knowledge of this problem deserves careful consideration. For this reason, when Lindblom's method of roentgenographic visualization of the intervertebral disk came to our attention, we decided to investigate its potentialities.

In 1948 Lindblom,[1] of Sweden, published his description of a method of direct injection of the intervertebral disk with a rapidly absorbable water-soluble contrast substance. Although only 15 disks had been so examined, he considered the method of great practical value and superior to myelography in accuracy. In 1950 he published the results of injection of 52 lumbar intervertebral disks.[2] The purpose of this preliminary report is to discuss our experience with the injection of 169 disks. One of the cases has previously been reported by Wise and Weiford.[3]

TECHNIC

The technic which we employ is as follows: The patient assumes a modified knee-chest position by bending over a table equipped with a knee rest. A rolled blanket beneath the abdomen increases the lumbar flexion. The tube and the Bucky diaphragm are arranged for a lateral roentgenogram. The skin is thoroughly prepared, and then injection of procaine is made at the proposed site of puncture. A 21-gage needle, 2½ in. (6.3 cm.) in length, is inserted between the spinous processes, directed toward the disk and advanced into the spinal canal. The stylet is

From the Cleveland Clinic and the Frank E. Bunts Educational Institute.

Read before the Section on Nervous and Mental Diseases at the One-Hundredth Annual Session of the American Medical Association, Atlantic City, June 15, 1951.

1. Lindblom, K.: Diagnostic Puncture of Intervertebral Disk in Sciatica, Acta orthop. scandinav. **17**:231, 1948.

2. Lindblom, K.: Technique and Results in Myelography and Disk Puncture, Acta radiol. **34**:321, 1950.

3. Wise, R. E., and Weiford, E. C.: X-Ray Visualization of Intervertebral Disk, Cleveland Clin. Quart. **18**:127 (April) 1951.

then removed, and a 26-gage needle, 3½ in. (9 cm.) in length, is passed through the shorter heavier needle until it encounters bone or enters the intervertebral disk. The position of this needle is then checked by means of a lateral roentgenogram and altered if necessary. Lindblom recommends fluoroscopic control of the needle insertion. In our hands this measure has not been satisfactory because of difficulty in visualization of the fine needle, especially in the fifth interspace. The fine 26-gage needle is employed to minimize the trauma of the disk puncture while the 21-gage needle, serving as a sheath, gives it the necessary rigidity.

Iodopyracet injection (35% diodrast[3]) is used as the contrast substance. One-half to 2 cc. is injected into the disk by means of a 2-cc. Luer-Lok syringe. Lindblom recommends a mixture of procaine and iodopyracet (parabrodil). We do not

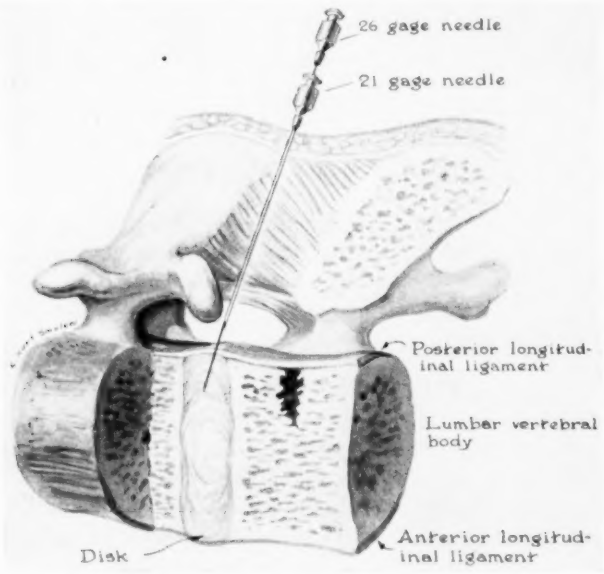

Fig. 1.—Schematic drawing showing position of needles.

add procaine since we believe that any pain produced is due to distention of the disk, with resulting pressure on the neighboring ligaments and nervous elements, which are beyond the locus of direct action of the injected material. Immediately after the injection, lateral and anteroposterior roentgenograms are made with the needles in situ.[4]

THE X-RAY PICTURE

The normal disk usually exhibits a bilocular collection of dye which occupies approximately the middle third of the disk in both lateral and anteroposterior projections. This appearance is due to pooling of the dye in the potential spaces

4. For this purpose we have used a Hodges head machine equipped with a 200 ma. transformer and a rotating anode x-ray tube. This arrangement permits making anteroposterior and lateral roentgenograms without moving the patient, by placing the x-ray tube to the side of or beneath the table.

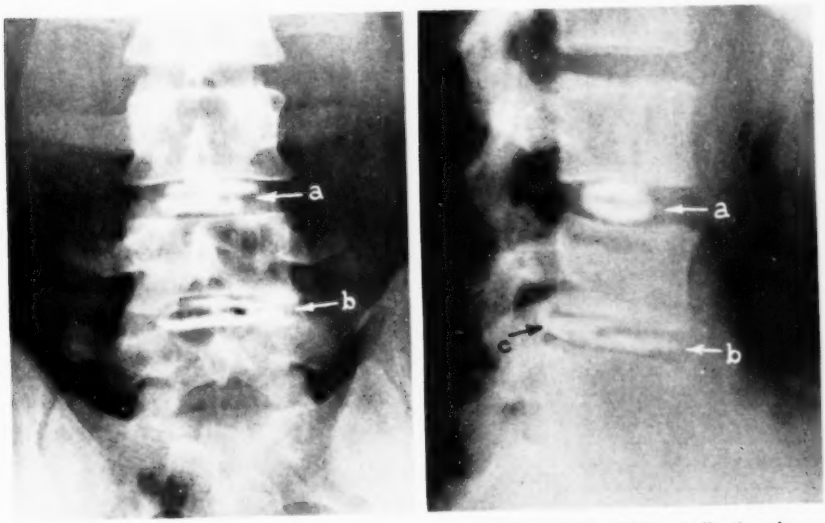

Fig. 2.—*a*, normal disk at third interspace; *b*, flattened irregular shadow indicating degenerated disk; *c*, posterior protrusion of disk. (Protruded disk on left found at surgery.)

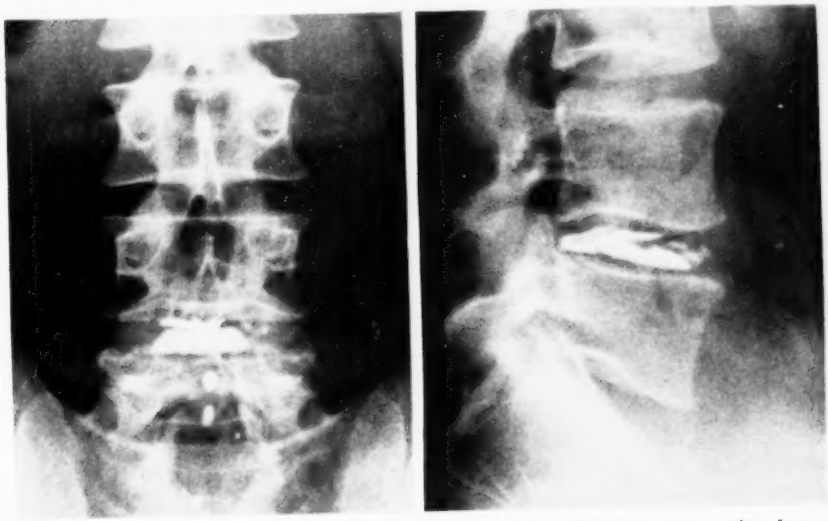

Fig. 3.—Flattened irregular shadow with loss of bilocular configuration representing degenerated disk. (No protrusion of disk found at surgery.)

which separate the normal nucleus from the cartilaginous plates. Injection of the normal disk is made against great resistance; it is usually painless, but mild local back pain may result. Pain radiating down the leg is not produced.

A second type of picture, described by Lindblom as a "degenerative" type of nucleus, is frequently seen. In this picture the dye shadow is not discrete and bilocular but is spread in an irregular fashion throughout almost the entire disk and may extend slightly beyond the margins of the bodies of the vertebrae. We believe that this represents a rupture of the nucleus pulposus without rupture of the outer layers of the annulus fibrosus. The injection of this so-called degenerated disk is also made against considerable resistance and is usually painless. This

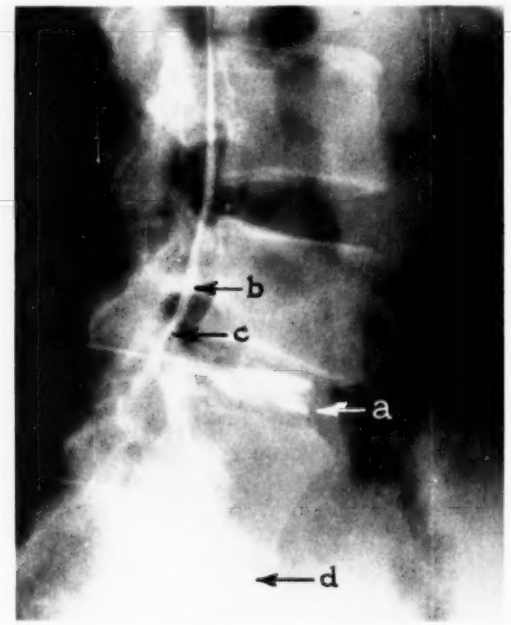

Fig. 4.—*a*, slight flattening and slight elongation of nucleus pulposus; *b*, extrusion of dye into epidural space; *c*, indentation of column of epidural dye by protrusion of disk. *d*, degenerated disk without protrusion. (Protruded disk found at fourth lumbar space at surgery.)

type of disk, we believe, is asymptomatic although its relationship to low back pain, and perhaps also sciatic pain, remains to be settled.

The third, or symptomatic type, is the degenerated disk with posterior protrusion. This usually shows a picture similar to the above type plus the presence of dye beneath the posterior spinal ligament, which is seen to bulge into the lumen of the spinal canal. Dye frequently is extruded into the epidural space, and this column of dye may show a concave deformity caused by pressure of the protruding annulus against the dural sac. In these cases the injection encounters less resistance, and the patient's sciatic pain is frequently reproduced by the injection.

THE CLINICAL RESULTS

In this study 186 injections were attempted on 89 patients, and 169 satisfactory diskograms were obtained. In 17 instances satisfactory roentgenograms were not obtained because of failure to introduce the needle into the disk, inability to inject the dye, or rapid disappearance of the injected dye. Thirteen of these failures were at the fifth interspace. In 12% of the cases it was necessary to puncture the annulus more than once in order to obtain satisfactory positioning of the needle. In the disorganized disk the diodrast[4] may disappear in a matter of minutes. In the normal disk traces of it may be apparent on the roentgenogram up to 12 hours after injection. However, in one case the dye disappeared from the normal disk in four hours and was still detectable in the pathologic disk after 13 hours.

Fifty-four disks on which satisfactory diskograms had been obtained were explored in 48 patients. In 46 of these a diagnosis of posterior protrusion of mild to severe degree had been made from the roentgenograms. In 39 of these 46, a protrusion was found at surgery of sufficient degree to explain undoubtedly the patient's symptoms. In two-thirds of these proved cases the patient's sciatic pain was reproduced by the injection, while in one-third of them dye was seen to have escaped into the epidural space. These protrusions were invariably at the level shown on the diskograms, and the eight disks on which negative diskograms had been obtained and which were investigated at these same operations all proved to be normal. Likewise, in two patients operated on on the basis of the clinical picture, and despite negative diskograms, protruded disks were not found.

In 7 of the 46 disks, or 15%, a false positive diagnosis had been made in the sense that the protrusion disclosed at operation was not considered to be sufficient to explain the patient's symptoms. Five of the roentgenograms showed the presence of dye in the epidural space. (Prior to this present analysis undue reliance had been placed on the latter finding even when unaccompanied with other convincing evidence of posterior protrusion of the disk.) Four of these seven cases were interpreted as showing a "significant" degree of protrusion and three as showing "very slight" protrusion. In none of these seven cases was there narrowing of the interspaces, and in each the bilocular character of the dye shadow was preserved to some extent. In none was the patient's leg pain reproduced by the injection. It is apparent on review of these cases that what was at the time considered to be a pathologic protrusion represented a normal convexity of the disk which was outlined by dye beneath the posterior spinal ligament.[5]

In those disks on which satisfactory diskograms had been obtained, 38 narrowed interspaces were recorded on the plain roentgenograms. All of these showed degenerated disks with or without posterior protrusions. In 18 of the 39 surgically proved protruded disks the involved interspace was found to be narrowed on the plain roentgenograms.

5. In these seven instances of false positive diagnosis, the intraspinal exploration was incidental to a previously planned spinal fusion in one case. In a second case the clinical diagnosis was not a protruded disk but nerve root adhesions from a previous disk operation, and the latter proved to be correct. In the third case a protruded disk was found at the fourth interspace, as diagnosed from the roentgenogram but the fifth disk, which was also thought to protrude slightly, was found to be normal. In the four remaining cases, none of which was entirely typical from the clinical standpoint, laminectomy was performed on the basis of the diskogram diagnosis with negative findings. Two of the patients were relieved of their sciatica, one was helped, and one obtained no relief.

MORBIDITY OF THE PROCEDURE

What can be said regarding the morbidity of the procedure? In the six months which cover this study, from one to three disks have been injected in each of 89 patients. Forty-one of the patients have been on conservative management for periods varying from one to seven months following injection, and none has returned with new or different symptoms which could be attributed to the injection of the disk. Forty-eight patients have been operated on, and of these one patient suffered a complication from the injection. His case is as follows:

The patient was a man of 36 years with a rather typical clinical picture of a protruded intervertebral disk. There was some diminution of the Achilles reflex suggesting that the lesion was in the fifth disk, but definite weakness in extension of the toes implicated the one above. There were no sensory changes. On April 16, 1951, the fourth and fifth disks were each injected with 1.5 cc. of 35% diodrast.® The fourth was considered normal; the fifth was considered ruptured and protruded. The patient's sciatic pain was reproduced by the injection of the fifth disk. He was sent home for a trial on conservative care.

When he got out of bed on the fourth day after injection severe pain developed in the back and he was found to have some fever. There was no sciatic pain. On his admission to the hospital seven days after the diskogram he would scream with pain in the lower back on the slightest movement. There was mild fever but no leukocytosis, and the spinal fluid was normal. He improved with antibiotic therapy. At laminectomy, 28 days after the disk injection, the posterior spinal ligament was found to be perforated and a curet introduced through this perforation into the disk encountered a cavity containing granulation tissue, the culture of which revealed Staphylococcus albus. Microscopic study of tissue removed from the cavity in the disk disclosed necrosis of fibrocartilage with areas of granulation tissue. There was pronounced infiltration by neutrophils and a rare giant cell of foreign-body type. No bacteria were seen. The pathologic diagnosis was chronic suppurative inflammation and necrosis of intervertebral disk with granulation tissue and slight foreign-body reaction.

The patient was placed on antibiotic treatment after operation, and no evidence of wound infection developed. Four weeks have now elapsed since operation, and he still has mild back pain when in the erect position for a time. We believe that the complication in this case was due to the introduction of Staphylococcus albus into the disk at the time of injection. It would appear that the tissue of the intervertebral disk, with its absence of blood vessels and, therefore, presumably poor resistance to infection, should provide an excellent place for the growth of bacteria even though relatively nonpathogenic. It indicates the need of careful aseptic technic during the disk rupture.

With this exception, the gross and microscopic appearance of the disk material removed from a few hours to three weeks after injection has been found to be no different from that removed in similar cases in which diskography was not performed.

SURVEY OF LITERATURE ON DISK DAMAGE BY LUMBAR PUNCTURE

The experience with the above cases led to a review of reported cases of pathologic changes in disks produced by lumbar puncture. A high percentage of these were found to have followed the intrathecal administration of antimeningococcic serum. Billington[6] recorded 35 cases of backache following meningitis. All patients had undergone one or more lumbar punctures. Seven of these showed subsequent narrowing of intervertebral spaces and 12 showed lipping, spurring, and other hypertrophic changes of the vertebral bodies.

6. Billington, R. W.: Spondylitis Following Cerebrospinal Meningitis, J. A. M. A. **83**:683 (Aug. 30) 1924.

Stump [7] recorded one case in which backache, narrowed interspace, destructive changes in the bodies, and limitation of motion were present five months after lumbar puncture while the patient was undergoing treatment for meningitis. Epps [8] observed a similar case.

Downing,[9] Wilson,[10] and Everett [11] reported a total of four cases presenting similar clinical picture of backaches, narrowed interspaces, and some limitation of motion following lumbar puncture for spinal anesthesia. Two cases [12] showed associated changes in the vertebral bodies. One case [10] came to surgery, and a protrusion of the disk was found.

Hussey,[13] Everett,[11] James,[14] Gellman,[15] and Pease [16] described 17 cases of persistent back pain following lumbar puncture for various diagnostic purposes. X-ray examination in these cases showed narrowing of the interspaces, and in most of them there were associated changes in the bodies, such as sclerosis and irregularity of the margins.

These 58 case reports implicate lumbar punctures as the cause of pathologic changes in lumbar disks. They present certain features in common. In many cases the pain on movement was of such severity as to require immobilization in a plaster jacket. All patients were apparently relieved completely or helped considerably by rest except one in whom the disk was associated with sciatica and was treated surgically. This is the only case in which a protrusion of the disk was actually proved. In none of the other cases was sciatica present. In many, the changes in adjacent bodies were much more marked than those seen with protruded intervertebral disks. The localized back pain and limitation of motion appear to have been severer than is usually seen with protrusions. Thirty-seven of these 58 patients had meningitis at the time of the lumbar punctures.

Many of the above cases resemble our case, in which septic necrosis of the disk was proved to have followed the puncture. The analysis suggests that most of the reported cases were also of infectious origin rather than due to simple trauma, as some of the authors suggest. The high incidence of changes in the disk following lumbar puncture in cases of meningitis as compared with cases without infection is a potent argument in favor of an infectious rather than a traumatic basis. The early

7. Stump, J. P., and Narins, S. A.: Intervertebral Disk Injury During Spinal Puncture, U. S. Nav. M. Bull. **41**:400 (March) 1943.

8. Epps, P. G.: Case of Degeneration of Intervertebral Disk Following Lumbar Puncture, Proc. Roy. Soc. Med. **35**:220 (Jan.) 1942.

9. Downing, F. H.: Collapse of Intervertebral Disk Following Spinal Puncture: Report of 2 Cases, U. S. Nav. M. Bull. **43**:666 (Oct.) 1944.

10. Wilson, J. N.: Prolapsed Intervertebral Disk After Lumbar Puncture, Brit. M. J. **2**:1334 (Dec. 10) 1949.

11. Everett, A. D.: Lumbar Puncture Injuries, Proc. Roy. Soc. Med. **35**:208 (Jan.) 1942.

12. Downing,[9] Everett.[11]

13. Hussey, B. J.: Collapsed Intervertebral Disk Following Lumbar Puncture, Proc. Roy. Soc. Med. **36**:379 (Feb.) 1943.

14. James, U.: Collapsed Intervertebral Discs Following Lumbar Puncture, Proc. Roy. Soc. Med. **39**:134 (Jan.) 1946.

15. Gellman, M.: Injury to Intervertebral Discs During Spinal Puncture, J. Bone & Joint Surg. **22**:980 (Oct.) 1940.

16. Pease, C. N.: Injuries to Vertebrae and Intervertebral Disks Following Lumbar Puncture, Am. J. Dis. Child. **49**:849 (April) 1935.

and pronounced narrowing of the interspace commonly described in these cases is evidence of necrosis and absorption of the disk, which was certainly present in our case.[17]

SUMMARY

In summary, we find that by the injection of diodrast® it is possible in a high percentage of cases to differentiate between a normal disk, a degenerated disk, and a degenerated disk with posterior protrusion. The normal disk is usually characterized by a pooling of the diodrast® in the spaces above and below the intact nucleus, producing a bilocular shadow. In the protruded disk this bilocular shadow is seldom present. Reproduction of sciatic pain during the injection occurred in two-thirds of the cases of proved protrusion. This sign should not be relied on when not accompanied with roentgenographic visualization of a protrusion of the disk. In approximately one-third of the cases of surgically proved protruded intervertebral disk, some of the injected dye was visible in the epidural space on the roentgenograms. The presence of dye in the epidural space, however, is not pathognomonic of a tear of the posterior spinal ligament and is of significance only when accompanied with roentgenographic evidence of protrusion.

In our hands the procedure has not been free of morbidity. In one of 89 patients, septic necrosis of the disk developed after injection. The procedure does not require hospitalization, although in a few instances the sciatic pain reproduced by the injection was so severe that intravenous administration of thiopental (pentothal®) sodium was required to complete the injection.

Increasing experience with this test should lead to greater accuracy in interpretation and a better understanding of the disk syndrome. It provides a method of direct visualization of the pathologic process as contrasted with the indirect evidence afforded by myelography. It is too early as yet to determine the relative accuracy and morbidity of these two procedures.

Incidentally, this method has demonstrated two features of clinical significance. The first is that an extremely slight increase in the height of the protrusion, such as is produced by the injection of 0.1 cc. of fluid into the disk, may be responsible for the exacerbations which characterize the syndrome of the protruded disk. The second is that the symptoms of pathologic changes in the disk which occasionally follow lumbar puncture are probably due to low-grade infection introduced into the disk by the needle rather than to mechanical trauma to the posterior spinal ligament, to the annulus, or to the nucleus pulposus.

We feel that more experience is needed to establish the value of this procedure. It has certain disadvantages, as follows: 1. It is not free of morbidity. 2. Considerable care and experience are necessary in accomplishing the injection and in interpreting the results. 3. It may result in the overlooking of a tumor of the cauda equina which would have been readily disclosed by myelography.

17. Sosman, in discussing cases of spondylarthritis presented by Saenger (Saenger, E. L.: Spondylarthritis in Children, Am. J. Roentgenol. **64**:20 [July] 1950), mentioned several cases of disk infections following lumbar punctures with needles which had not been properly sterilized. Keyes and Compere (Keyes, D. C., and Compere, E. L.: Normal and Pathological Physiology of Nucleus Pulposus of Intervertebral Disk: Anatomical, Clinical and Experimental Study, J. Bone & Joint Surg. **14**:897 [Oct.] 1932) showed experimentally that protrusion of a disk may follow incision of the annulus fibrosus, but no proof of a protrusion following insertion of an instrument as fine as a 26-gauge needle has been found. The needle used in a lumbar puncture is, as a rule, much larger than this.

ABSTRACT OF DISCUSSION

DR. W. EDWARD CHAMBERLAIN, Philadelphia: Dr. Gardner and his group are to be congratulated for this fine piece of work. Their scientific exhibit was a great help to me. It should be studied by all who are interested in Dr. Lindblom's method.

At Temple University Hospital, after Dr. Lindblom's personal visit in Oct. 1950, Dr. Jeffery P. Moore, of our department of radiology, and Dr. Victor Reyes, of the department of neurosurgery, developed the necessary teamwork and have carried out the procedure with a large measure of success. Like Dr. Gardner, we have sometimes found it difficult to interpret our findings, especially with reference to the epidural spread of the dye, mentioned by Dr. Gardner. It has been our feeling that we can avoid meaningless epidural spreads of the iodopyracet injection by leaving the needle in the disk until after the roentgenograms have been exposed. When the needle has been withdrawn prematurely, we may find some of the dye extruded along the needle track into an epidural distribution, in the absence of any abnormality of the annulus or protrusion of disk material.

Our work has all been done under fluoroscopic guidance. It has seemed to us that the fluoroscope (we used a special type for this work) has helped us a great deal. With its help we have succeeded in introducing the needle into the disk at every attempt with one exception. In other words, we have had only one disk that could not be entered with our needle. In this case the subsequent surgical exploration revealed a greatly narrowed disk space, due to advanced degeneration of the disk.

We feel that Dr. Gardner and his group have made a real contribution to the technic of this procedure through their introduction of the 21-gauge and 26-gauge needles (in place of the 18-gauge and 22-gauge needles) which we have used and which have been advocated by Dr. Lindblom.

DR. FREDERICK P. MOERSCH, Rochester, Minn.: When I was asked to discuss Dr. Gardner's paper, I had hopes that our surgeons would have enough experience with diskography by the time of this meeting so I might report on their work. Unfortunately, we have been tardy in taking up this work and our experience is very limited.

A point which one might stress is that the reason for diskography in the lumbar area is the anatomic relationship of the dural sac to the emerging nerve roots. Because of this situation, the usual myelogram may fail to show the presence of a protruded disk. Dr. Gardner mentioned this, but it bears repeating. Our surgeons have noted that after diskography there is a little tendency for bleeding to occur at the time of operation. Therefore, they have suggested that the operative procedure be postponed for a few days following the test. I should like Dr. Gardner's comment on this point.

Lindblom, in summing up his experience, which dates back to 1946, stated that the procedure of diskography should be employed only in a selected group of cases; this, too, would be our opinion from the limited experience we have had up to the present time.

Dr. Gardner has answered a question I had in mind, namely, the question of whether there are any ill effects from diskography.

A final point to bear in mind is that in spite of care one may mistake the presence of a tumor for a disk syndrome. I wonder if Dr. Gardner has had such an experience? Has he seen any ill-effects as a result of bleeding due to puncture of a tumor in the caudal region?

DR. RALPH B. CLOWARD, Honolulu, Hawaii: I should like to compliment Dr. Gardner on presenting what I consider the most important advance in our treatment of ruptured disks since we started treating ruptured disks. I think we have here a diagnostic tool which is almost foolproof, if it is properly applied.

The indication is that a diskogram, however, should warrant some serious consideration, and I have formed my own criteria for this. I do not make a diskogram on a patient in the stress of sciatica; I prefer to make a myelogram. I make all my own myelograms in 10 or 15 minutes and give the patients fluoroscopic examination.

A large percentage of patients with the disk syndrome, with herniation of a disk and clinical evidence of compression of the nerve root, will have positive myelograms.

It is in the cases in which there is no sciatica but disabling back pain that I should like to know if the pain is due to a ruptured disk. We who perform a lot of industrial surgery see

many cases of disabling, recurrent backache of which there are no objective signs. The patients go on, month after month and year after year, laying off work and being paid for disability, and we are expected to find out what is wrong with them and what can be done.

With the diskogram, even though the disk has not herniated into the spinal canal, we can demonstrate that the nucleus pulposus has been ruptured, the disk has been broken, and the patient has a loose, unstable vertebral joint, which can be treated surgically.

I appreciate Dr. Gardner's demonstration of this procedure to me last November. I have done it in about 20 cases since, and we have uncovered a lot of interesting pathological findings in the disk which we were unable to demonstrate before.

One patient showed a marked anterior protrusion of the anterior longitudinal ligament. On exploration at operation, with a wide exposure of the interspace to enable us to see into the interspace, we found a very large fragment of the disk which had been completely torn from the body of the vertebra and jammed far anterior and had made the balloon-like protrusion of the anterior longitudinal ligament into the abdominal cavity. The contour of the dye outlining the anterior longitudinal ligament was identical with the goose-bill spurs which we see in the spine in so-called arthritis, many of which are due to collapsed disks.

As I said in the beginning, I think the diskogram is an extremely important contribution to disk surgery, and we are going to be able to make a diagnosis in many disk cases and treat the patients before they get sciatica.

DR. W. JAMES GARDNER, Cleveland: Most of the credit for this work was not due to the neurosurgical service but the industry and enthusiasm and complete cooperation which Dr. Hughes and Dr. Wise, of the x-ray department, have furnished.

We have not had any trouble with bleeding after this procedure. I think that added experience will convince the neurosurgeons that it does not occur. The disk, of course, is completely avascular. There may be, and in many cases is, a little spilling of the dye into the epidural space, which, however, we have not found to cause any difficulty.

Another interesting fact which this examination has taught us is that in cases in which there was narrowing of the interspace on the plain roentgenograms the diskogram is never normal. The nucleus is always disorganized in these cases.

Dr. Cloward has suggested employing this method in the study of patients with backache without sciatica. We have tried that, but I do not know how to interpret the roentgenograms. There is no proof that a narrowed space and a disorganized disk are the cause of the backache. With added experience, however, it may help to solve this problem.

We feel at the present time that it is important to inject the dye into the posterior portion of the annulus and not attempt to get it into the nucleus because it is the posterior portion of the disk in which we are interested. Of course, we must be careful of depending too much on mechanical aids in our diagnosis, but this is a method which appeals to me because it outlines the pathologic process directly instead of indirectly, as in myelography. We feel that we have a better understanding of the pathology of the intervertebral disk since we have been employing this method.

We have not had enough experience to compare the morbidity of this procedure with that resulting from myelography. We had one complication which might have been serious but was not. However, myelography is not without morbidity.

Dr. Moersch pointed out that it would be possible by this method to overlook a tumor which would be readily picked up by a myelogram. We feel, therefore, that diskography should never be undertaken without previous examination of the spinal fluid, which will certainly disclose most of the cases of tumor.

REDUCTION IN ELEVATED CEREBROSPINAL FLUID PRESSURE BY ARTIFICIAL KIDNEY

Experiments on Acute Overhydration in Renal Insufficiency

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AND
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ST. LOUIS

THE THERAPY of acute renal failure, with the possibility of reversing an outwardly hopeless situation by readjustment of the body fluids and electrolytes, is a fascinating problem. This problem is the more demanding of a solution because acute renal insufficiency can so often occur in patients whose outlook is otherwise excellent. The etiology of the so-called uremic syndrome has not been definitely proved, but the occurrence of fluid overloading is frequent.[1] On the assumption that pulmonary and cerebral edema play an important role, this work was undertaken to determine the efficiency of extracorporeal dialysis in the therapy of this particular ramification of the problem of the uremic syndrome.

Preliminary reports of Kolff [2] and Alwall [3] were available at the beginning of our work, and we are indebted to them for their pioneer efforts. The apparatus of Alwall, with a few minor modifications, was used because of its simplicity combined with the added advantage of the elimination of the blood pump.

The theory of extracorporeal dialysis has been discussed amply in previous papers. A few comments seem appropriate here. The principle is based on the diffusion of ions across a differentially permeable membrane. The appropriate membrane has an available pore area [4] which limits passage of larger molecules. The membrane chosen for this work probably allows passage of molecules up to

From the Department of Surgery, Washington University School of Medicine.

1. Strauss, M. B.: Acute Renal Insufficiency Due to Lower Nephron Nephrosis, New England J. Med. **239**:693, 1948.

2. Kolff, W. J., and Berk, H. T. J.: The Artificial Kidney: A Dialyser with a Great Area, Acta med. scandinav. **117**:121, 1944. Kolff, W. J.: New Ways of Treating Uremia, London, J. & A. Churchill, Ltd., 1947.

3. (*a*) Alwall, N.: On the Artificial Kidney: I. Apparatus for Dialysis of the Blood in Vivo, Acta med. scandinav. **128**:317, 1947. (*b*) Alwall, N.; Norviit, L., and Steins, A. M.: Clinical Extracorporeal Dialysis of Blood with Artificial Kidney, Lancet **1**:60, 1948. (*c*) Alwall, N., and Norviit, L.: On the Artificial Kidney: II. Effectivity of Apparatus, Acta med. scandinav., Supp. 196, p. 250, 1947; (*d*) III. Technical and Methodological Problems, ibid. **131**:237, 1948.

4. Weech, A. A., and Michaelis, L.: Studies on Permeability of Membranes: Mensuration of Dried Collodion Membrane (Calculation of Dimensions and of Relations to Certain Biological Membranes), J. Gen. Physiol. **12**:221, 1928.

35,000 molecular weight.[3] Practically, the membrane is a long length of cellophane sausage tubing through which the blood is allowed to circulate. The tubing is immersed in a dialysate of known ionic concentration. The removal or return of ions or water to the blood is regulated by varying the ionic and particle concentration of the dialyzing fluid and the hydrostatic pressure which the blood must overcome to pass through the tubing and return again to the body.

APPARATUS AND TECHNIQUE

The apparatus consists of a long length of cellophane tubing (previously sterilized by boiling) which is wrapped around a large drum of monel metal and flattened against the drum by an outer stainless steel screen. Variations in the tightness of this screen make it possible to vary the volume-surface ratio to one which seems most efficient under the conditions of the experiment. The metal drum, tubing, and screen are immersed in a large lucite® cylinder. The actual volume of the container is reduced to 12 liters of dialyzing solution because of the displacement of the monel drum. The fluid is constantly being replaced by solution directed into the bottom of the lucite® cylinder from large carboys overhead. The incoming solution is warmed by an immersion heater controlled by a thermostat. By bubbling oxygen-carbon dioxide mixture through a perforated ring in the bottom of the cylinder, the solution is kept well mixed and partially oxygenated. The dialyzing solution was circulated at the rate of 12 liters per hour. Activity of the apparatus could be varied in four ways, namely, by changing the blood flow through the tubing, changing the volume-surface ratio of the tubing, changing the composition of the dialyzing solution, and varying the level of the fluid in the bath in reference to the heart of the subject. A blood flow of 100 to 300 cc. of blood per minute was utilized, depending usually on the size of the artery in use.

Actually, in the experiments at hand, the volume-surface ratio and the blood flow were not under immediate control of the operators during the experiment. The hydrostatic pressure could be varied easily: first, by the addition or withholding of osmotically active particles in the preparation of the ever-changing dialysate (dextrose was the only substance used in this manner throughout the experiments), or, second, by the adjustment of the level of dialysate in reference to the subject's heart, thereby determining the back "venous pressure" which regulated the pressure in the artificial "capillary wall." Because of the simplicity of this final method, it is believed that Alwall's ultrafilter would be a more efficient apparatus.[3c]

Mongrel dogs weighing 14 to 20 kg. were used as experimental animals. All dogs were given heparin supplied by the Abbott Company, the dosage varying from 75 to 150 mg., depending on the size of the dog and the duration of the dialysis. Exact minimum dosage was determined accurately by Alwall in rabbits and set at 1 to 2 mg. per kilogram per hour.[6] (Merrill has been able to make 150 mg. suffice

5. Fishman, A. P.; Kroop, I. G.; Leiter, H. E., and Hyman, A.: Experiences with the Kolff Artificial Kidney, Am. J. Med. **7**:15, 1949.

4. Weech, A. A., and Michaelis, L.: Studies on Permeability of Membranes: Mensuration ences During the Study of Dialytic Treatment on Animals with Uremia Caused by Mercuric Chloride Poisoning, Acta med. scandinav. **132**:477, 1949.

for human dialysis.[7]) There were no hemorrhages of note in the serous cavities or in or about any of the organs. We noted no difficulty from hemorrhage around the cannulae providing about five minutes elapsed between the time of closure of the wound around the cannulae and the heparinization of the animal. Alwall's more complicated method of leading the cannulae out through separate wounds, allowing 24 hours to elapse prior to heparinization, was not found necessary.[8] At the completion of the experiment protamine was used to counteract the heparin in the dogs to be saved. The animals seemed to suffer no ill effects of ligation of the vessels in the groin. All experiments were carried out under pentobarbital sodium (nembutal®) anesthesia. The dog's circulation was placed in continuity with the dialyzer, with a minimum of friction to impede the blood flow. Glass cannulae were placed in the femoral artery and vein and attached to uniform-caliber rubber tubing. On the arterial side a side tube was placed leading to a direct-pressure manometer, and on the venous side a bubble trap and a Baxter filter were introduced. Also on the venous side was an inlet for intravenous administration of fluid and a simple bubble-type flow meter. The tubing, rubber and glass, the filters, and other apparatus in contact with the blood, except the cellophane tubing, were coated with General Electric dri-film® to diminish coagulation.[9] This was effective in reducing clotting and reducing the amount of heparin used in the experiment. We found no need for a blood pump as the heart supplies sufficient blood to circulate 6 to 10 liters per hour through the dialyzer. The dead space in the cellophane tubing was filled with either 5% dextrose solution or isotonic sodium chloride solution. We thought at first that whole blood would be necessary but found no evidence of circulatory disturbance with the solutions as used.

EXPERIMENT

For experimental subjects we desired uremic animals which suffered from overloading of the body tissues with administered fluids. The animals were first subjected to bilateral ureteral ligation. Then, 48 hours after ureteral ligation, 100 cc. of fluid per kilogram of body weight was given intravenously in a short period, usually one hour. Fluid given was either 5% dextrose in water or 0.85% saline solution. These two fluids were selected because of their general use in renal failure therapy. The tissues within the central nervous system were taken as an index of the status of body edema, and the cerebrospinal fluid pressure was used as a gross indicator of changes occurring. The cerebrospinal fluid pressure was measured by cisternal puncture and a spinal fluid manometer. Readings of pressure in millimeters of spinal fluid were made at fifteen-minute intervals throughout the experiment. Observations were made on two groups of dogs. 1. In the controls, after routine

7. Merrill, J. P.; Thorn, G. W.; Walter, C. W.; Callahan, E. J., III, and Smith, L. H., Jr.: The Use of an Artificial Kidney: I. Technique, J. Clin. Invest. **29**:412, 1950. Merrill, J. P.; Smith, S., III.; Callahan, E. J., III, and Thorn, G. W.: The Use of an Artificial Kidney: II. Clinical Experience, ibid. **29**:425, 1950.

8. Alwall, N.; Bergsten, B. W. B.; Godden, P. O.; Norviit, L., and Steins, A. M.: On the Artificial Kidney: IV. The Technique in Animal Experiments, Acta med. scandinav. **132**:393, 1949.

9. Björk, V. O.: Brain Perfusions in Dogs with Artificially Oxygenated Blood, Acta chir. scandinav. (Supp. 137) **96**:1, 1948. Jaques, L. B.; Fidlar, E.; Feldsted, E. T., and Macdonald, A. G.: Silicones and Blood Coagulation, Canad. M. A. J. **55**:26, 1946.

ureteral ligations and rapid intravenous administration of fluid the course of the cerebrospinal fluid pressure was measured and recorded for five hours. No therapy was given, and no dialysis was performed. The controls were divided into those given 5% dextrose in water and those given 0.85% saline solution intravenously. 2. In the other group, after routine ureteral ligations and rapid intravenous administration of fluids, dialysis was begun one hour after conclusion of the fluid administration. In both groups the weight of the animal was recorded at intervals on a continuously weighing scale and hematocrit determinations were performed.

OBSERVATIONS

1. With the administration of 0.85% saline solution a definite rise in cerebrospinal fluid pressure occurred in control dogs (both ureters had been ligated previously). This rise was a steep one and continued as long as the fluid was given. There was definite correlation between the rate of rise and the rate of fluid adminis-

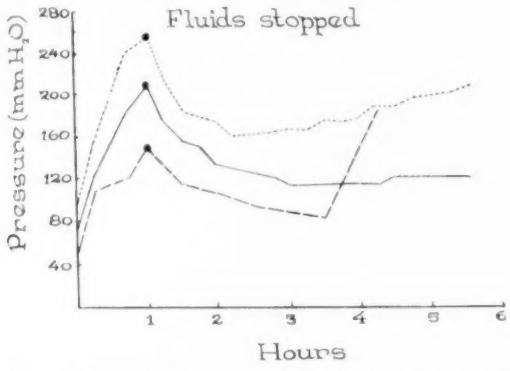

Fig. 1.—Effect on cerebrospinal fluid pressure of rapid infusion of 0.85% saline solution, 100 cc. per kilogram of body weight. Composite of Experiments S-1, S-2, and S-3.

tration. After the cessation of the administration of fluid the cerebrospinal fluid pressure fell rapidly to lower levels, but in no case did it return to the base-line level. After this a lag period ensued averaging one hour. This lag period was followed by a secondary rise of varying degree. The secondary rise did not usually reach its peak in the period of five hours allowed for observation. (See Figure 1, which is a composite of experiments S-1, S-2, and S-3.)

With the administration of 5% dextrose in water an initial rise in cerebrospinal fluid pressure was again seen, followed by a lag period of about one hour. This in turn was followed by a secondary rise of much higher magnitude than that noted with infusion of 0.85% saline solution. The secondary rise was always higher than the initial rise and was at times two to three times as high. (Fig. 2, experiments G-1, 2, and 3.)

The initial rise and secondary rise occurred in a similar pattern in every control case. No definite change in pulse or blood pressure was seen although there was a slight tendency toward slow pulse rates with very high cerebrospinal fluid pressure.

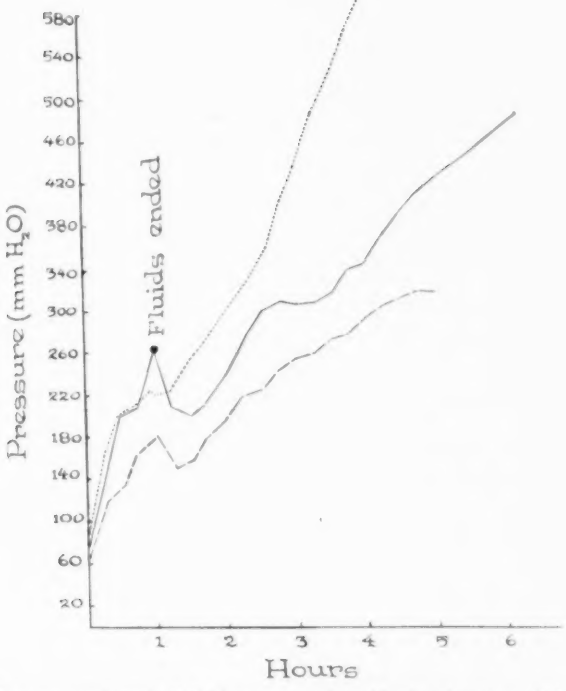

Fig. 2.—Effect on cerebrospinal fluid pressure of rapid administration of 5% dextrose in water, 100 cc. per kilogram of body weight. Composite of Experiments G-1, G-2, and G-3.

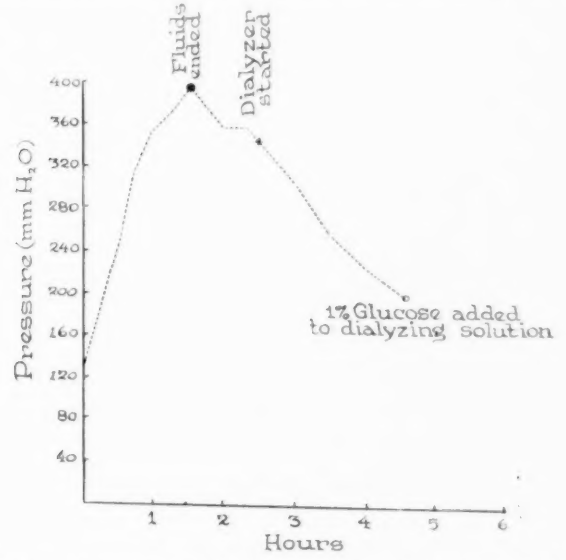

Fig. 3.—Effect on the cerebrospinal fluid pressure of rapid administration of 5% dextrose in water (100 cc. per kilogram) followed by dialysis with the artificial kidney. Approximately one hour after the completion of intravenous fluid administration, dialysis was begun with 1% dextrose, 0.6% sodium chloride, 0.04% potassium chloride, and 0.2% sodium bicarbonate in the dialyzing solution. The dialysis resulted in complete suppression of the secondary rise. Compare with Figure 2, in which the secondary rise in cerebrospinal fluid pressure following the administration of 5% dextrose in water is illustrated.

2. After the establishment of the control curves, similar uremic specimens were prepared. However, after the lag phase, when the onset of the secondary rise could be predicted, the dialyzer was connected to the dog and dialysis begun. Because of the more pronounced secondary rise with the use of 5% dextrose in

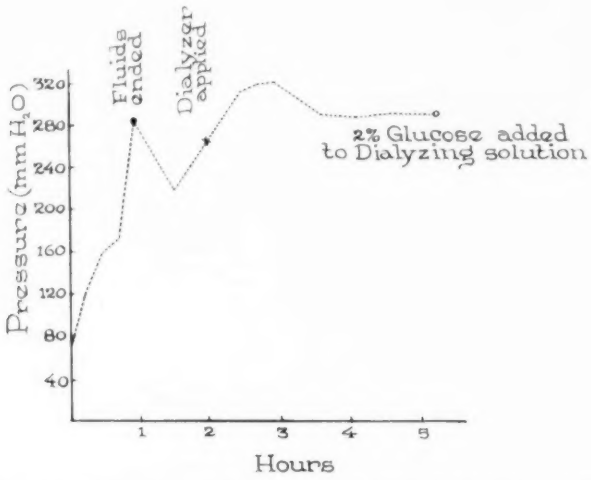

Fig. 4.—Effect on the cerebrospinal fluid pressure of rapid administration of 5% dextrose in water (100 cc. per kilogram) followed by dialysis with the artificial kidney. Two per cent dextrose was used in the dialyzing solution.

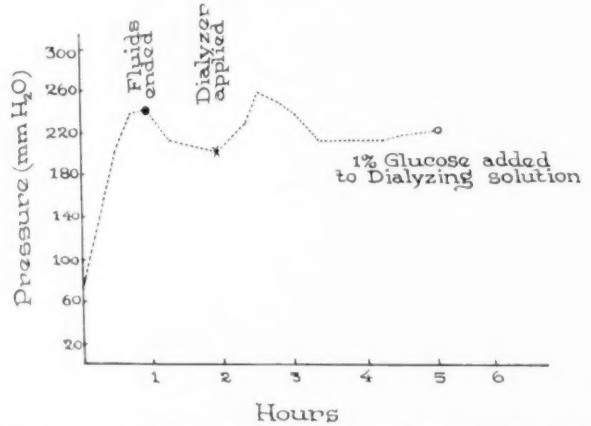

Fig. 5.—Effect on the cerebrospinal fluid pressure of rapid administration of 5% dextrose in water (100 cc. per kilogram) followed by dialysis with the artificial kidney. One per cent dextrose was used in the dialyzing solution. The upward continuation of the pressure curve seen in Figures 4, 5, and 6 after application of the dialyzer is discussed in the text.

water as the intravenously administered solution, this substance was used throughout for preparation in the cases in which dialysis was to be carried out.

The application of the dialyzer produced marked modification of the rather definite pattern already seen in the secondary rise in the control animal. In no case

was the secondary rise as high as that seen with the controls, and in every case a downward trend could be detected (Figs. 3, 4, 5, and 6). The continuation upward of the secondary rise after the dialysis had been started in Figures 4, 5, and 6 may be occasioned by the further dilution of the animal's blood volume by the amount of 5% dextrose in water used to fill the cellophane tubing, or time may be required for dialysis to become effective in counterbalancing the effect of the intravenously administered solution. Previous fluid balance status may contribute to the variability in response. In any case the upward continuation seen in these three experiments indicates that changes in blood dynamics occasioned by the sudden application of the dialyzer have little or nothing to do with the effect produced. Blood pressure and pulse rates at this time were little affected.

As seen in Figure 6, the addition of a large amount of dextrose to the dialysate with the increase of tonicity of this fluid produced a marked fall in the cerebrospinal

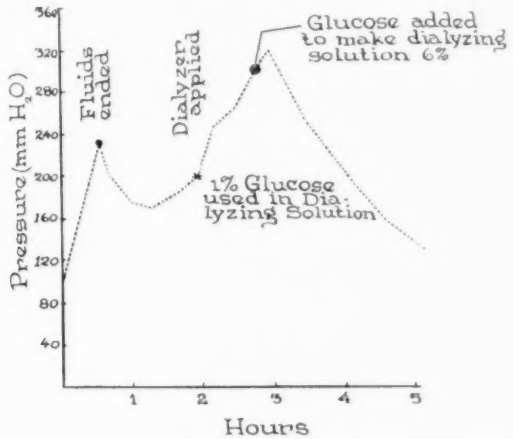

Fig. 6.—Effect on the cerebrospinal fluid pressure of rapid administration of 5% dextrose in water (100 cc. per kilogram) followed by dialysis with the artificial kidney. One per cent dextrose was used originally in the dialyzing solution, and dextrose was added to make the solution up to 6% dextrose after one hour.

fluid pressure. No attempt was made to utilize Alwall's ultrafilter principle[36] except to insure an adequate distance between dialysate level and the subject's heart. This distance was kept constant in all experiments reported here. The amount of fluid removed was determined approximately by repeated weight measurements. The hematocrit value showed a drop from fluid administration. This was followed by an increase which never rose to base-line levels, as no experiment was carried to the point of complete removal of the edema.

COMMENT

It is fully realized that the method of producing edema and its measurement are open to criticism. The speed of edema production compared to that usually seen in clinical cases is a disadvantage. Also, irregular intakes of the preparations during the 48 hours after ureteral ligation and vomiting made completely comparable con-

ditions impossible. During infusion and dialysis, diarrhea was seen and fluid losses into the bowel were impossible to measure.

However, the observations are sufficiently constant to allow deductions which may be of some help in the final integration of factors causing the uremic state.

The initial rise of cerebrospinal fluid pressure may be explained on the basis of the initial increase in blood volume within the cranial cavity. The secondary rise is probably due to passage of fluid into the tissues causing edema. The more marked effect seen with 5% dextrose in water is probably due to its easier cellular diffusibility.

The "secondary rise" in cerebrospinal fluid pressure was first reported by Weed and McKibben [10] and others. These observations led to the use of hypertonic solutions in the therapy of increased intracranial pressure. It has been seen that the secondary rise is less pronounced with sucrose or sorbitol, presumably because their sugars have large molecules which have difficulty in traversing the hematoencephalic barrier.[11] It may be that the secondary rise seen in our experiments have been more pronounced, first because of the molecular characteristics and secondly because of the large amount of water used as compared to that used when hypertonic solutions are employed. With the lack of kidney function in uremia, the secondary rise of cerebrospinal fluid pressure following intravenous fluid administration may be more pronounced. The severe morbid state of uremia may be induced or accentuated by fluid overloading.[1] The experiments performed show that the acute overhydration in renal insufficiency may be alleviated by the use of the extracorporeal dialyzer.

We believe that the improvement seen in cerebrospinal fluid pressure with dialysis is due to removal of water. The charts indicate water removed and pressure decreased. Confirmatory evidence of removal of fluid was found in weight measurement and in hematocrit values. The importance of removing water alone rather than whole blood has been discussed by Alwall.[12]

SUMMARY

An extracorporeal dialyzer which embodies some slight modifications of the Alwall dialyzer is described.

Experimental uremia and acute overhydration were produced in dogs. Serial measurements of cerebrospinal fluid pressure gave an indication of the hydration and edema within the cranial cavity and the body in two types of experiments, one on controls and one on dialysis.

Removal of water from the circulating blood of the experimental animal by extracorporeal dialysis resulted in a definite decrease in cerebrospinal fluid pressure.

The possible relations and importance of these observations to clinical cases of uremia are briefly discussed.

10. Weed, L. H., and McKibben, P. S.: Pressure Changes in the Cerebrospinal Fluid Following Intravenous Injection of Solutions of Various Concentrations, Am. J. Physiol. **48**:512, 1919.

11. Bulloch, L. T.; Gregeron, M. A., and Kinney, R.: Use of Hypertonic Sucrose Solution Intravenously to Reduce Cerebrospinal Fluid Pressure Without Secondary Rise, Am. J. Physiol. **112**:82, 1935.

12. Alwall, N.; Eglitis, P.; Norviit, L., and Tornberg, A.: On the Artificial Kidney: Influence of Saline with High Glucose Content on Fluid Balance of Rabbits Treated by Dialysis, Acta med. scandinav. **137**:233, 1950.

INTESTINAL SURGERY IN INFANTS AND CHILDREN SIMPLIFIED BY THE USE OF MULTITOOTHED CLAMPS

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AND
WILLIS J. POTTS, M.D.
CHICAGO

THE PURPOSE of this paper is to present an aid in the technique of intestinal anastomosis in infants and children.

In 1946 [1] a new type of many-toothed clamp for use in vascular surgery was described. It has been demonstrated that this clamp, with tiny teeth in the apposing jaws, will not slip and will not injure the vessel wall. These clamps were originally devised, and are routinely being used, for division and suture of a patent ductus arteriosus. Since then, larger clamps embodying the same principle have been constructed for resection of coarctation of the aorta.[2] Several different curved modifications of this clamp have been designed, and their use in portacaval anastomosis has been described.[3]

An opportunity for the use of these clamps in intestinal surgery first presented itself during an operation for Meckel's diverticulum in a 3-year-old child. The base of the diverticulum was divided between ductus clamps. About 3 mm. of the base of the diverticulum was left protruding beyond the proximal clamp. There was no leakage of intestinal contents and no bleeding from the mucosa. The stump of the diverticulum was closed with a continuous suture of 0000 chromic catgut placed in the mucosa. The clamp was then removed and the serosa closed with inverting sutures of interrupted 0000 black silk.

When the clamp was released, there was no evidence of gross injury to the bowel wall. Only a small row of fine dots remained where the tiny teeth had penetrated the serosa. It seemed worth while to conduct a series of experiments on animals to determine the adaptability of these clamps to all types of intestinal surgery.

LABORATORY PROCEDURES

Seven dogs varying from 20 to 40 lb. (9.1 to 18.1 kg.) in weight were operated on under intravenous pentobarbital sodium (nembutal®) anesthesia. No special preoperative preparation of the intestinal tract had been carried out. The operations

From the Children's Memorial Hospital.

1. Potts, W. J.: A New Clamp for Surgical Division of the Patent Ductus Arteriosus, Quart. Bull., Northwestern Univ. M. School **22**:321, 1948.

2. Potts, W. J.: Technique of Resection of Coarctation of the Aorta with Aid of New Instruments, Ann. Surg. **131**:466, 1950.

3. Riker, W. L.; Nielsen, A., and Potts, W. J.: A Technique of Portacaval Anastomosis, Ann. Surg. **132**:937, 1950.

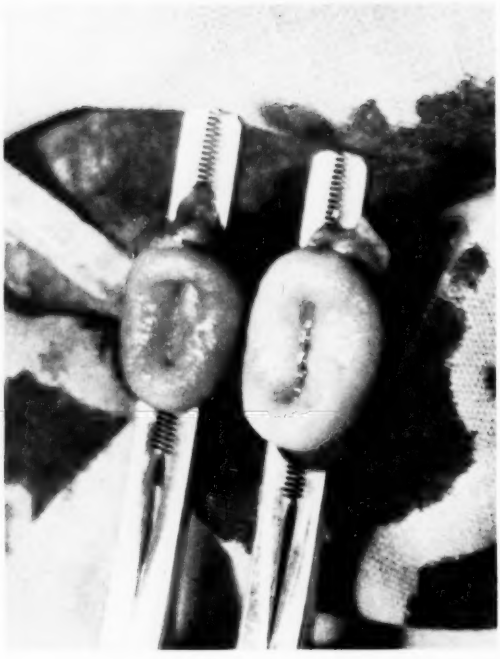

Fig. 1.—Clamps applied to small intestine for an end-to-end anastomosis.

Fig. 2.—Clamps applied for an end-to-side anastomosis between ileum and cecum.

performed were as follows: resection and end-to-end anastomoses of the jejunum, ileum and transverse colon; resection and end-to-side and side-to-side anastomosis of the ileum to the cecum, and resection and side-to-side anastomosis of the jejunum.

A similar technique was used in all cases. Ductus clamps were used on the small bowel, and coarctation clamps on the large bowel. Curved clamps were used in performing end-to-side and side-to-side anastomoses (Figs. 1 and 2).

A short loop of intestine to be resected was isolated. The clamps were applied to the bowel approximately 10 cm. apart and allowed to remain for 20 minutes. The clamps were then removed and reapplied 5 cm. proximal to and distal from the previously clamped segment. This clamped segment of bowel was resected, about 7 mm. of intestinal wall being left protruding beyond each clamp. The open cut ends of the bowel were thoroughly cleansed of fecal material with gauze saturated with a 1 to 1,000 solution of benzalkonium (zephiran®) chloride.

Gross examination of the resected bowel revealed only a row of tiny dots on the serosa where the teeth of the clamp had embedded themselves. The clamped portion of bowel was placed in Zenker's solution and sectioned for microscopic study.

A standard technique of anastomosis was used. The clamps are rotated, and the posterior row of interrupted 0000 black silk sutures are placed in the seromuscular layer. These sutures are placed about 3 mm. apart and 3 mm. from the cut end of the bowel. The clamps are rotated back, and with a continuous over-and-over stitch of 0000 chromic catgut the ends of the mucosa are coapted. An anterior row of seromuscular sutures of interrupted 0000 black silk completes the anastomosis. The opening in the mesentery is repaired with interrupted 0000 black silk.

In end-to-side and side-to-side anastomosis the clamps are not rotated. The posterior seromuscular layer is sutured first, the knots being left on the inside. The mucosa and anterior seromuscular layers are then sutured as previously described.

RESULTS

After surgery the dogs were given only water for 24 hours and then a regular diet. There were no postoperative complications.

The animals were again operated on at intervals varying from 24 hours to 8 weeks. Each site of anastomosis was resected and examined grossly and microscopically. The anastomoses at 24 hours showed normal minimal edema. The rows of fine dots in the serosa where the clamps had been applied were not visible. The anastomoses inspected at intervals from one to eight weeks showed good healing.

Microscopic sections made across the area of the bowel where the clamp had been applied revealed, as was anticipated, occasional small rents in the serosa where the teeth had penetrated. However, in no case was there any evidence of injury to the muscularis, submucosa, or mucosa.

Microscopic sections made through the completed anastomosis at the end of one to eight weeks showed normal healing with a narrow area of fibrous union between the two bowel segments.

Other procedures were carried out on the small intestines of dogs to determine whether the teeth might cause immediate weakness in the bowel wall. Large segments of small intestine were removed and clamped in several places. One end of the removed segment was tied tightly. The other end was attached to a sphygmomanometer to allow inflation to any desired pressure. The bowel was then inflated to a pressure of 150 mm. of mercury and placed under water. No leakage of air occurred at any of the areas where clamps had been applied. This same test was used with similar results on the colon and esophagus of a dog and on an isolated segment of jejunum removed from a newborn baby during operation for intestinal atresia. Really, it is surprising that multiple sharp teeth in these clamps do not penetrate the intestinal mucosa. Since demonstrating rather conclusively that the clamps will not injure the bowel wall we have used them routinely in all intestinal surgery on infants and children.

Clinical use of these instruments is briefly reported in the following varied types of intestinal surgery.

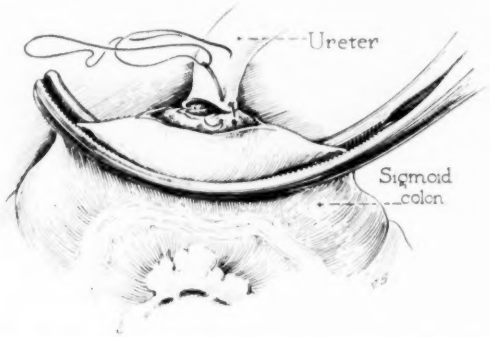

Fig. 3.—Occlusion of a segment of bowel with a curved clamp during ureterosigmoid anastomosis.

Case 1.—A. V., a 28-hour-old baby, was admitted to the hospital with clinical and x-ray evidence of jejunal atresia. At operation a jejunal atresia was found about 2 ft. (61 cm.) from the ligament of Treitz. The greatly dilated proximal segment was aspirated with a large needle to reduce its size. The small distal segment was injected with saline solution to increase the size of the lumen and to demonstrate patency. Ductus clamps were applied to the two ends of the bowel, and an end-to-end anastomosis was performed by Dr. Stephen Gans, using two layers of interrupted 00000 black silk. The infant made an uneventful postoperative recovery.

Case 2.—E. B., a 22-month-old white boy with exstrophy of the bladder, was admitted to the hospital on Oct. 24, 1950, for a right ureterosigmoidostomy. The technique described by Nesbit [4] was used, suturing the ureter to the sigmoid, mucosa to mucosa, with interrupted sutures of 0000 chromic catgut. The spoon-shaped, curved, toothed clamp was placed tangentially on a portion of the sigmoid to prevent escape of intestinal contents from the incision in the sigmoid (Fig. 3). The postoperative course was uneventful. On November 28, the patient was readmitted to the hospital for a left ureterosigmoidostomy, performed by the same technique.

4. Nesbit, R. M.: Ureterosigmoid Anastomosis by Direct Elliptical Connection; Preliminary Report, Univ. Hosp. Bull., Ann Arbor **14**:45, 1948.

CASE 3.—D. A., a 6-year-old white boy, was first admitted to the hospital on Aug. 17, 1950, with multiple polyposis of the entire colon. From August, 1950, to January, 1951, he was admitted on five separate occasions for proctoscopy and fulguration of polyps in the rectum and rectosigmoid. In February, 1951, he was again admitted to the hospital for colectomy and ileoproctostomy. The curved, multitoothed clamp was applied to the rectosigmoid at the level of the peritoneal reflection. The colon was divided less than 1 cm. proximal to the clamp. Another curved clamp was applied to the ileum about 12 cm. from the ileocecal valve. The ileum was divided about 7 mm. distal to the clamp. The almost right-angle handles of these clamps made it easy to bring the ileum down to the rectum and perform the anastomosis in the pelvis. The clamps held the two ends of the bowel steady while the sutures were placed. There was no spillage of fecal material, and there was no bleeding to obscure the operative field.

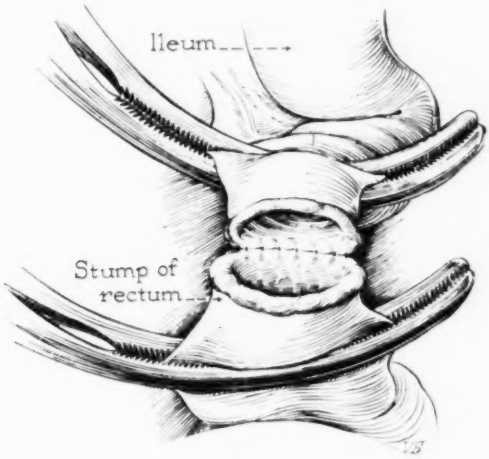

Fig. 4.—End-to-end anastomosis of ileum to rectum at the peritoneal reflection.

COMMENT

The multitoothed clamps are easy to handle. They prevent leakage of intestinal contents and bleeding from the cut end of the bowel; they will not slip, and yet they cause minimal trauma to the wall of the gastrointestinal tract.

The ordinary rubber-shod intestinal clamps are only moderately satisfactory for most intestinal surgery in adults. Always cumbersome and difficult to manipulate, such clamps are especially so in abdominal surgery in a baby. The thin edge of the multitoothed clamp allows the surgeon to see exactly what he is doing and how much bowel has been clamped off. Since the clamps will not slip, the danger of sudden spillage and gross contamination is eliminated.

CONCLUSIONS

Multitoothed clamps are a distinct aid to intestinal surgery in infants and children. Their safety has been demonstrated by laboratory studies on animals and by clinical use.

VOLVULUS OF THE CECUM

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VOLVULUS of the cecum is a rare disease. Our interest in this subject was stimulated by three cases occurring recently at the Boston City Hospital. The purpose of this paper is to review briefly the condition and add three cases to the literature.

The incidence of volvulus of the cecum as a cause of intestinal obstruction varies with different authors. Sweet [1] reported an incidence of 1.15% of 520 cases of intestinal obstruction seen at the Massachusetts General Hospital. Young, Morrison, and Wilson [2] found an incidence of 1.4% at the Faulkner Hospital. Other reported incidences have been 1.4% at the Touro Infirmary [3] and 4.3% at the Albany Hospital.[4]

Although occurring at any age, this condition is chiefly a disease of young adults. The majority of cases appear between the ages of 20 and 50.[4]

The predisposing cause of cecal volvulus is hypermobility of the cecum. In a classical study of 125 normal adult cadavers, Wolfer, Beaton, and Anson [5] found that in 11.2% the cecum was sufficiently mobile to permit a volvulus. In addition one third of these possessed a fixed ileum which could function as a point around which the torsion could occur. This hypermobility of the cecum is due to faulty development of the right colon. The right colon attains its normal position by three processes, i. e., rotation, descent, and fixation. A defect in fixation, which normally occurs from the eighth month of fetal life until about four months after birth, may result in hypermobility.

From the Boston City Hospital.

Dr. Byrne is Assistant Professor of Surgery, Boston University School of Medicine; Dr. Swift is Chief Resident, Boston City Hospital, and Dr. Farrell is Resident, Department of Radiology, Boston City Hospital.

1. Sweet, R. H.: Volvulus of the Cecum: Acute and Chronic with Reports of 8 Cases, New England J. Med. **213**:287-293 (Aug. 15) 1935.

2. Young, E. L.; Morrison, H. R., and Wilson, W. E., Jr.: Volvulus of the Cecum and Ascending Colon, New England J. Med. **237**:78-86 (July 17) 1947.

3. Browne, D. C., and McHardy, G.: Acute and Chronic Cecal Volvulus, Am. J. Digest. Dis. **9**:177-180 (May) 1942.

4. Donhauser, J. L., and Atwell, S.: Volvulus of the Cecum, A Review of 100 Cases in the Literature and a Report of 6 New Cases, Arch. Surg. **58**:129-148 (Feb.) 1949.

5. Wolfer, J. A.; Beaton, L. E., and Anson, B. J.: Volvulus of Cecum: Anatomical Factors in Its Etiology; Report of Case, Surg., Gynec. & Obst. **74**:882-894 (April) 1942.

Many inciting causes of cecal volvulus have been described. A high-residue diet may be responsible for the very high incidence of volvulus found in Eastern Europe. Pregnancy is occasionally associated with cecal volvulus, in which case the causative factor is either displacement of the cecum by the enlarged uterus or hyperperistalsis due to the nausea and vomiting of pregnancy. Postoperative adhesions sometimes serve as a fixation point around which torsion can occur and may have been responsible for the volvulus in two of the cases being reported. Obstruction of the colon distal to the cecum in association with violent peristalsis from either catharsis or enteritis has caused the condition. Various kinds of direct and indirect trauma have been implicated, i. e., coughing, lifting, jumping, or blows to the abdomen.

The direction of the volvulus is supposed to occur more frequently in a clockwise direction, i. e., twisting from right to left. There may be some relation between the direction of the torsion and the position of the ileocecal valve on the cecum.[5] In two of the cases being reported the volvulus was counterclockwise, and in one it was clockwise.

The signs and symptoms of volvulus of the cecum vary with the extent and duration of the pathologic process. Initially, as the twist commences, there will be intermittent, crampy pain, usually located in the right lower quadrant but which may occur anywhere in the right side of the abdomen. As the torsion continues and causes intestinal gas and fluid to become trapped in the cecum, the pain becomes severer and continuous. Distention occurs which is limited at first to the right side of the abdomen and is associated with nausea and vomiting. When the circulation to the intestine becomes impaired, gangrene of the bowel wall may take place. When this occurs or is impending, there will be tenderness and muscle rigidity over the volvulus associated with absent peristalsis, tachycardia, fever, and leucocytosis. Since the ileum is involved in the torsion, there will be accompanying signs and symptoms of small bowel obstruction, i. e., periumbilical crampy pain, generalized distention, nausea, and vomiting.

The diagnosis of volvulus of the cecum depends on an awareness of the disease and on a complete history and physical examination. Close cooperation with a radiologist is of utmost importance, since it is generally agreed that x-ray examination is the best diagnostic procedure. There are varying reports by radiologists as to the accuracy of making a preoperative diagnosis.[6]

The most typical finding on a flat roentgenogram of the abdomen is a markedly dilated loop of cecum and ascending colon which usually assumes a transverse position in the middle or upper abdomen. It is visualized on the right side overlying the vertebral column and extending for a varying distance to the left. Associated with this there is an absence of a large-bowel gas pattern in the right lower quadrant, where the cecum should normally be seen. These characteristic findings may be seen in Figures 1 and 2. When there is small-bowel obstruction, it will also

6. (*a*) Dixon, C. F., and Meyer, A. C.: Volvulus of the Cecum, S. Clin. North America **28**:953-963 (Aug.) 1948. (*b*) McGraw, J. P.; Kremen, A. J., and Rigler, L. G.: The Roentgen Diagnosis of Volvulus of the Cecum, Surgery **24**:193-804 (Nov.) 1948. (*c*) Jungman, H.: Volvulus of the Caecum, Brit. J. Radiol. **21**:346 (July) 1948. (*d*) Ritvo, M., and Golden, J. L.: The Roentgen Diagnosis of Volvulus of the Sigmoid with Intestinal Obstruction, Am. J. Roentgenol. **56**:480-488 (Oct.) 1946. (*e*) Easton, E. R., and Adams, J. E.: Incipient Volvulus of the Cecum Associated with Left Sided Colon: Report of Case, with New X-Ray Sign Obtained by Barium Enema, Surgery **1**:920-927 (June) 1937. (*f*) Young and others.[2]

be seen on a flat roentgenogram. Sometimes the dilated small-bowel loops will be seen in unusual locations in the right upper quadrant (Fig. 1) and will aid in making the diagnosis of ileocecal volvulus.

It is unwise to resort to a barium enema routinely in such cases.[6a] However, if the findings on the flat plate are not obvious and the condition of the patient permits, it may on occasion be necessary. The column of barium sulfate will be obstructed usually at the ascending colon or occasionally at the transverse colon. If a twisting mucosal pattern can be demonstrated at the site of torsion, the diagnosis is obvious. Easton and Adams reported a diagnostic sign which they considered of great importance in establishing the diagnosis:

> When in the course of a barium enema, the column of barium is unable to pass beyond a certain point in the region distal to the cecum . . . and when at the same time a large collection of gas appears at the site of the cecum indicating its patency and conformation, either in the midline or slightly to the right of it, this is a clear sign that volvulus of the cecum has taken place.[6b]

The treatment of ileocecal volvulus is necessarily operative and the proper definitive surgery depends on the findings at operation. Detorsion of the cecum must be accomplished in all cases. If the cecum is greatly distended and if its viability is questionable, it is wise to decompress it before attempting detorsion with either a needle or a suction trocar. Rupture of the cecum, with spillage of fecal contents, has occurred in many instances when this precaution was not taken. It occurred in Case 3 of this series.

The problem of fixation of the cecum to prevent further episodes of volvulus has been much discussed in the literature. When the cecum is greatly distended, a cecostomy is the procedure of choice, since it both decompresses the bowel and produces adequate fixation. When the cecum is not distended markedly, various methods of fixation have been advocated, i. e., plication of cecum or development of peritoneal flaps with suture of cecum beneath them. It is our opinion that even in these cases a cecostomy should be performed.

When the cecum is gangrenous, a resection of the bowel must be performed. Although in the past an obstructive resection was oftenest advocated, the tendency today is to perform a resection with immediate anastomosis. In desperately ill patients, however, a Mikulicz procedure may be lifesaving.

The prognosis depends, of course, on the extent of the pathological process. Donhauser and Atwell[4] reviewed 100 cases with an over-all mortality rate of 42%. When gangrene of the cecum was present, the mortality rate was 72%; without gangrene the mortality rate was 32%.

REPORT OF CASES

Case 1.—M. H., a white woman aged 68, was admitted to the Boston City Hospital with abdominal pain and vomiting of seven days' duration. The pain was present in the right upper abdomen, with occasional episodes in the right lower quadrant. It was crampy and nonradiating and was made worse by the ingestion of food or liquid of any kind. Vomiting of a brownish material usually followed the bouts of severe pain.

The patient had a long history of tuberculosis, having been in a sanatorium for 10 years. One year previously, she had been told that she had positive sputum, and roentgenograms of the chest revealed active tuberculosis. She had noticed a weight loss of 20 lb. (9.1 kg.) during the past six months associated with a productive cough.

Physical examination disclosed an emaciated, dehydrated white woman in moderate distress from abdominal distention. There were dullness and rales over the right lower and middle lobes of the lung associated with shallow and rapid breathing. The abdomen was moderately distended and diffusely tympanitic. There was tenderness in the right upper abdomen and just to the right of the umbilicus. No masses were felt, and rectal and pelvic examinations revealed no abnormalities. The temperature was 98.8 F., the pulse rate 100, and the respiratory rate 28. The blood pressure was 116/75. The white blood cell count was 8,700; hematocrit, 27; blood urea nitrogen, 45 mg. per 100 cc.; chlorides, 91 mEq., and total protein, 6.8 gm. The urine was essentially normal.

A preliminary diagnosis of acute cholecystitis was made, but because of the persistent vomiting and abdominal distention a flat plate of the abdomen was obtained (Fig. 1), and a diagnosis of volvulus of the cecum was made. The patient was then prepared for surgery.

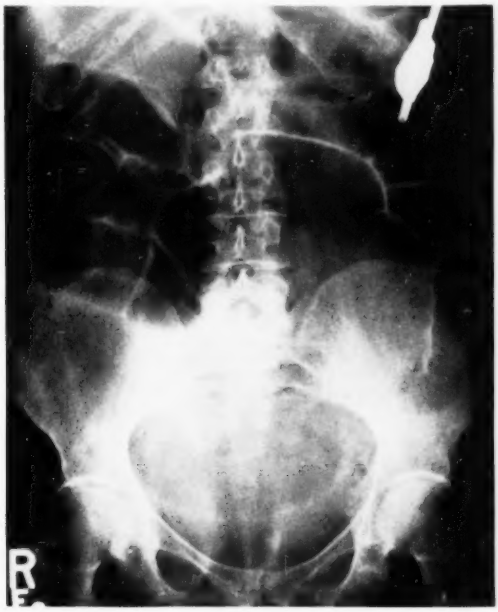

Fig. 1 (Case 1).—Flat roentgenogram of abdomen demonstrating (1) markedly dilated cecum extending into the left middle abdomen, (2) absence of large-bowel gas pattern in normal position of cecum and (3) dilated loops of small bowel in right upper quadrant.

With the patient under spinal anesthesia, the abdomen was entered through a right rectus muscle-splitting incision. The terminal ileum, cecum, and ascending colon were greatly distended and cyanotic and were rotated 180 degrees in a counterclockwise direction (twisted from right to left). The cecum was decompressed aseptically with the use of a suction trocar and was rotated back to its normal position. A tube cecostomy was then performed and the tube brought out through a McBurney type of incision in the right lower region of the abdomen. The laparotomy wound was closed in layers with a continuous No. 0 chromic catgut suture in the peritoneum, a continuous No. 28 stainless steel near-and-far suture in the rectus muscle, and fascia and interrupted black silk sutures in the skin.

The patient had a fairly normal postoperative course and by the sixth postoperative day was taking food and fluids. On the 12th postoperative day, phlebitis of the left leg and a pulmonary infarct developed. A bilateral superficial femoral division was performed. The

function of the gastrointestinal tract remained normal during the rest of her course, but she gradually went downhill from the pulmonary disease and cardiac failure and died on the 51st postoperative day.

CASE 2.—S. McG., a 51-year-old white woman, was admitted to the Boston City Hospital because of abdominal distention of two days' duration. She had had multiple sclerosis for many years, but her only abdominal difficulty had been chronic constipation. Five days prior to her entry she took a cathartic, and afterwards she had crampy abdominal pain near the umbilicus and nausea and vomiting. This persisted for several days until she noticed that her abdomen was distended markedly.

Physical examination revealed an emaciated, middle-aged white woman, appearing acutely ill from abdominal distress. The abdomen was greatly distended and tympanitic, and peristalsis was absent. Tenderness was present over the entire abdomen in association with rigidity. There was a flexion contracture of both knees and hips, due to the neurologic disturbance.

Fig. 2 (Case 2).—Flat roentgenogram of abdomen demonstrating (1) markedly dilated cecum and ascending colon lying in a transverse position in the upper abdomen and (2) absence of a large-bowel gas pattern in the normal location of the cecum.

The temperature was 99.2 F., the pulse rate 140, and the respiratory rate 18. The blood pressure was 90/60. The white blood cell count was 11,900; hemoglobin, 10.5 gm. per 100 cc.; blood urea nitrogen, 10 mg.; chlorides, 95 mEq., and carbon dioxide, 43 vol. %. Urinalysis gave negative results.

A flat roentgenogram of the abdomen was obtained (Fig. 2), and a diagnosis of volvulus of the cecum was made. The patient was prepared for surgery with the aid of a Harris tube, intravenous administration of fluids and a transfusion.

With the patient under ether anesthesia, the abdomen was opened through a right rectus muscle-splitting incision. A markedly distended and cyanotic cecum was discovered. Further exploration revealed that the tip of the cecum was bound to a scar in the abdominal wall (site of a previous appendectomy) by a single dense adhesion and a volvulus of 180 degrees in a clockwise direction had occurred around this. The adhesion was severed and the cecum

decompressed with the use of a Wangensteen suction trocar. This permitted detorsion of the cecum. A tube cecostomy was performed and the tube brought out through a McBurney incision. The laparotomy incision was closed in layers and reinforced with six stainless steel wire retention sutures.

The postoperative course was relatively uneventful, and the patient was discharged on the 29th postoperative day to the neurological service for further treatment of the multiple sclerosis. At this time the cecostomy site was almost completely closed.

CASE 3.—L. S., a 72-year-old white woman, was admitted to the Boston City Hospital with crampy abdominal pains. Four days prior to her entry there developed crampy generalized abdominal pains which were made worse by the ingestion of food and fluids. These pains continued to the time of entry and were associated with absent bowel movements and the gradual progression of abdominal distention.

The past history revealed that she had undergone a right nephrectomy 20 years previously.

Abdominal examination revealed marked distention and tympany throughout the entire abdomen. Peristalsis was high-pitched and hyperactive. No tenderness or rigidity could be demonstrated.

Laboratory data disclosed the following: The hemoglobin content was 12.5 gm. per 100 cc.; hematocrit, 42%; white blood cell count, 14,000; fasting blood sugar, 120 mg. per 100 cc., and blood urea nitrogen, 19 mg. The stools did not contain occult blood.

A Harris tube was passed on the evening of the patient's entry to the hospital and the abdomen explored the next morning through a right rectus muscle-splitting incision. Examination demonstrated the ascending colon and cecum to be dilated to a diameter of 15 cm. The cecum was severely cyanotic and lay transversely in the midabdomen. It was twisted about 180 degrees in a counterclockwise direction. An adhesive band was severed which had connected the cecum to the region of the nephrectomy scar, and detorsion was performed. While this was being done, a perforation of the cecum took place, with much spillage of fecal matter. The perforation was closed in two layers, and a cecostomy was done by suturing the cecum to the skin of a right McBurney incision. The laparotomy incision was closed in layers and reinforced with stainless steel wire retention sutures.

The postoperative course was complicated by a wound infection, which cleared rapidly. Three weeks after this operation a barium enema revealed a constricting lesion in the lower sigmoid. Accordingly, a resection of this was performed, and pathological examination demonstrated "diverticulitis of the rectosigmoid with fibrosis and stricture of the bowel lumen." Several weeks later the cecostomy was closed, and the patient was discharged from the hospital.

SUMMARY

The subject of volvulus of the cecum has been briefly reviewed, and three cases of this condition are presented. A correct preoperative diagnosis can be made from the characteristic findings on a flat roentgenogram of the abdomen. These characteristic findings are (1) a markedly dilated loop of cecum and ascending colon which usually assumes a transverse position in the middle or upper abdomen and (2) the absence of a large-bowel gas pattern in the normal location of the cecum. In the absence of gangrene, tube cecostomy is recommended as the procedure of choice after detorsion has been accomplished.

RESULTS OF PRIMARY INGUINAL HERNIOPLASTY

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EVALUATION of the result of the primary repair of inguinal hernia is of paramount importance. Since this is one of the commonest conditions requiring surgical intervention in man, it plays an important part in the economic, social, and employable status of the person involved. Great strides have been made in the surgical approach to this problem since the original basic anatomical repairs and reports of both Bassini [1] and Halsted.[2]

During the past 50 years, through the continued efforts and statistical evaluation of their results in large series of cases by many prominent groups and surgeons, this important problem has been presented many times. It is encouraging to note in the recent years the great improvement made in the technic and wider use of nonabsorbable suture for the repair of this congenital or acquired defect. Even though there exist today innumerable types of repairs which have their strong advocates, the more recent reported series reveal a decided lowering of the recurrence rates, which indicates that favorable progress is being made by the use of these various methods.

This report is based on a study of 564 unselected male patients who were operated on for primary repair of an inguinal hernia at this hospital between Sept. 1, 1946, and Sept. 1, 1949. In 78, or 13.8%, of this group the hernias were bilateral, making a total of 642 hernioplasties. In none of the cases was a bilateral repair accomplished simultaneously. The opposite side was repaired between the 7th and 10th postoperative days.

These operations were performed by 18 different members of the full-time, attending, and house staffs, using the same basic repair, which will be described later in this presentation.

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Dr. Emery was formerly a member of the Surgical Staff and is now located in Concordia, Kan.

Sponsored by the Veterans Administration with the approval of the Chief Medical Director. The statements and conclusions published by the authors are a result of their own study and do not necessarily reflect the opinions or policy of the Veterans Administration.

1. Summers, J. E.: Classical Herniorrhaphies of Bassini, Halsted and Ferguson, Am. J. Surg. **73**:87, 1947.

2. Halsted, W. S.: The Radical Cure of Inguinal Hernia in the Male, Bull. Johns Hopkins Hosp. **4**:17, 1893.

The patients were distributed throughout the various age groups, the greatest number falling in the 20 to 29 and 50 to 59 groups, representing 30.3 and 33.5%, respectively (Table 1). The youngest was 18, and the oldest was 76.

OPERATIVE TECHNIC

The operation performed in this entire series was a modification of the combined procedures of Bassini,[1] Halsted,[2] and Andrews.[3] This technic was developed by Skinner (one of us [L. T. P.] was formerly associated with him) many years ago and was performed in a large series of cases prior to this series.[4] Since that time additional minor modifications have been made in this technic.

In 616, or 95.9%, the operations were performed with the patients under spinal anesthesia. The remaining 26 operations, or 4.1%, were accomplished with the use of a general anesthetic.

A nonabsorbable suture material was employed in the entire series of cases. In the first 243, or 37.8%, of the operations, cotton was used; and in the last 399, or 62.2%, silk was the suture material.

TABLE 1.—*Hernia Incidence According to Age*

Age Group	Number
Under 20	10
20-29	171
30-39	97
40-49	56
50-59	189
60-69	38
Over 70	3
Total	564

An oblique skin incision is employed, beginning just above the pubic spine and extending upward to and about 5 cm. medial to the anterior-superior iliac spine. The external oblique aponeurosis is split in the direction of its fibers along the medial side of the cord (Fig. 1). This splitting results in a good medial and lateral leaf from this structure, which is important in the final stages of the repair.

After mobilization of the leaves of the external oblique aponeurosis, the cord structures are freed and displaced laterally from their bed. The indirect sac, if present, is dissected from the cord structures high up to the internal ring. If an associated direct weakness or sac is present, it is pulled up with the indirect sac, being freed from all the surrounding structures and dissected from the urinary bladder. This method converts the hernia into one sac. If an indirect sac is not present, the direct sac is picked up in the upper portion of Hesselbach's triangle. It is our opinion that a careful and complete dissection of the sac is extremely important. In many of the cases, a combined type of hernia existed (Fig. 2).

A high ligation of the sac is then carried out, usually by means of a purse-string suture, and the excess portion of the sac is excised. In the majority of cases the sac is transplanted and anchored to the abdominal wall. In the last three years silk

3. Andrews, E.: A Method of Herniotomy Utilizing Only White Fascia, Ann. Surg. **80**:225, 1924.

4. Skinner, H. L., and Duncan, R. D.: Inguinal Hernia: Report of 1,126 Cases, S. Clin. North America **25**:219, 1945.

has been the suture material of choice. In all cases, whether or not there is a direct hernia or weakness in Hesselbach's triangle, interrupted imbricating sutures of No. 000 silk are taken in the transversalis fascia and muscle. It is our opinion that

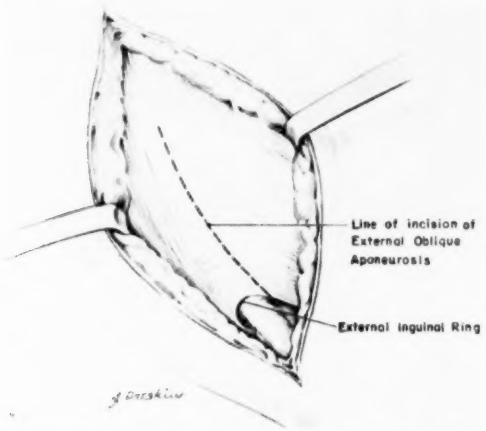

Fig. 1.—Dotted line represents the line of incision made in the direction of the fibers of the external oblique aponeurosis along the medial side of the cord.

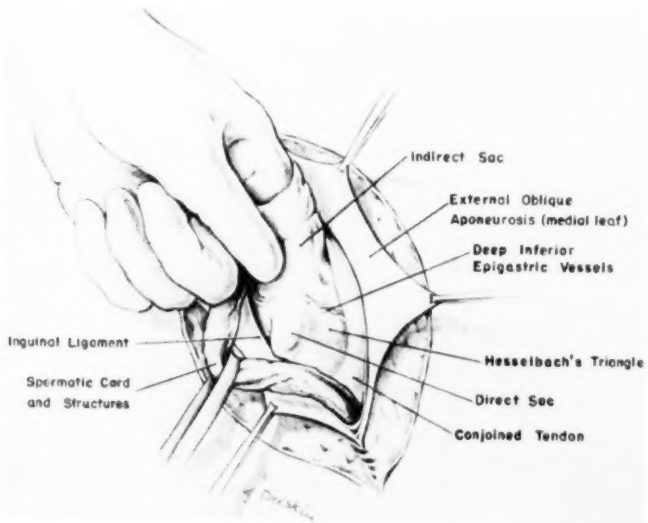

Fig. 2.—Represents the anatomical exposure obtained after division of the external oblique aponeurosis and displacement of the cord laterally from its normal position. The indirect sac has been dissected off the cord. The index finger is placed into the peritoneal cavity through the opening in the indirect sac, with the tip of the index finger in Hesselbach's triangle revealing weakness and the presence of a direct sac.

this is the first line of defense, and taking the relaxation out of this structure helps to form a solid foundation for the hernia repair. Usually three sutures in this area are sufficient (Fig. 3).

Since most recurrences develop in a defect immediately behind the pubic spine or at the internal ring, steps are taken to fortify these areas. A suture of No. 00 silk is placed over the pubic spine as a pulley stitch. The stitch is begun by placing the needle through the conjoined tendon, if present, or through the medial aspect

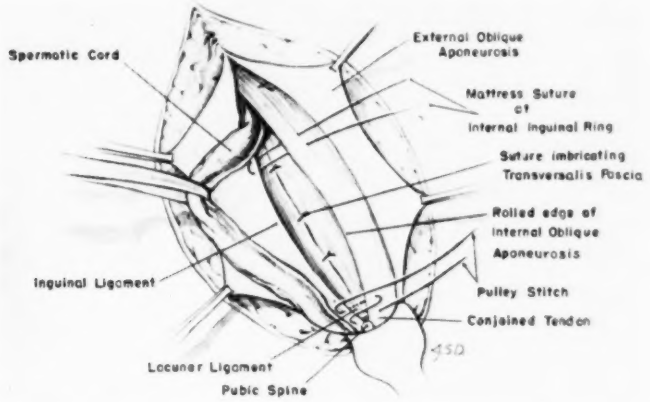

Fig. 3.—Interrupted sutures of 000 silk are tied imbricating the transversalis fascia and muscle in Hesselbach's triangle. A horizontal mattress suture is placed to form the lower border of the internal inguinal ring so as to bring the cord out of the abdomen at a right angle. The method of placing the pulley stitch to obliterate and reinforce the weak area behind the pubic spine is shown.

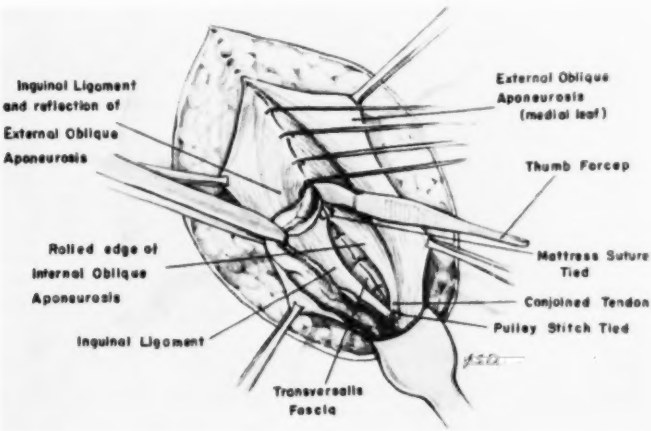

Fig. 4.—The pulley stitch and mattress sutures are tied. The rolled edge of the aponeurosis of the internal oblique is sutured to the inguinal ligament, using No. 00 silk. The blunt end of the thumb forceps indicates the relative size of the internal ring.

of the internal oblique aponeurosis above the pubic spine. The needle is then passed through the inguinal ligament at the point where it attaches to the pubic spine. It is important not to place the suture through the periosteum. This same suture is then continued as a parallel stitch, being brought up and through the internal

oblique aponeurosis close to the first one taken. The final step of this four-way stitch is to sweep upward behind the pubic spine area, the suture being placed through the lacunar ligament and coming out at the free margin of the inguinal ligament close to the suture taken above the pubic spine (Fig. 3). As this suture

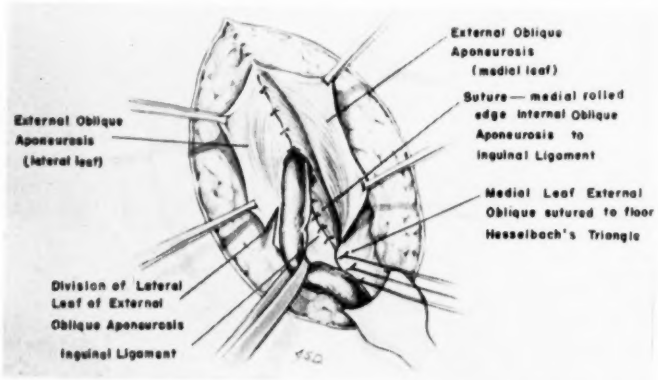

Fig. 5.—The second layer of aponeurosis-to-aponeurosis repair is depicted. The aponeurosis of the internal oblique or conjoined tendon is sutured to the shelving edge of the inguinal ligament in Hesselbach's triangle, using No. 00 silk. The lateral leaf of the external oblique aponeurosis is divided for a short distance ¾ in. (1.9 cm.) below the lower border of the internal ring. The medial cut leaf of the external oblique aponeurosis is sutured to the floor of Hesselbach's triangle, using No. 000 silk.

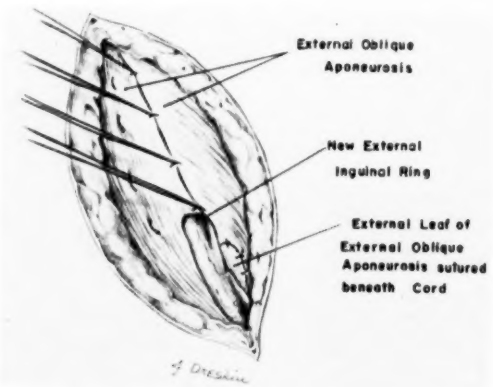

Fig. 6.—The cut medial and lateral leaves of the external oblique aponeurosis are imbricated beneath the cord in the region of Hesselbach's triangle, using No. 000 silk. The cut leaves of the same structure are sutured above the cord with interrupted sutures of the same size. The cord has been transplanted subcutaneously above the external oblique aponeurosis, and the newly formed inguinal canal is now only ¾ in. (1.9 cm.) in length, as compared with a former length of 2 to 2½ in. (5 to 6 cm.).

is tied, it approximates these structures superior to and over the pubic spine area, closing off this weak angle (Fig. 4).

The lower border of the internal ring is then formed by placing a horizontal mattress suture of No. 00 silk approximating the free rolled edge of the internal

oblique aponeurosis to the shelving portion of the inguinal ligament. This stitch is placed high so as to bring the cord out of the abdomen at right angles instead of obliquely (Figs. 3 and 4).

The upper border of the internal inguinal ring is then formed by suturing the rolled edge of the internal oblique aponeurosis to the inguinal ligament. The size of this ring is made in accordance with the size of the cord and its structures. In none of these cases was the size of the ring large enough to permit the entrance of the tip of the index finger. It is our opinion that the ring should be small. We feel that it is adequate in size if the large end of an ordinary-sized thumb forceps can be placed into it (Fig. 4).

The rolled edge of the internal oblique aponeurosis is then approximated to the inguinal ligament below and above the cord, using interrupted No. 00 silk sutures. These sutures are not placed under any tension and are tied so as to approximate the tissues without tension or without producing strangulation (Figs. 4 and 5).

The lateral leaf of the external oblique aponeurosis is split toward the inguinal ligament and at right angles to its fibers about three-fourths of an inch (1.9 cm.) below the lower border of the newly formed internal ring (Fig. 5). The divided

TABLE 2.—*Type of Hernia*

	Number	Per Cent
Indirect	385	59.9
Direct	114	17.7
Combined	136	21.4
Sliding	7	1.0
Totals	642	100.0

medial and lateral leaves of the external oblique aponeurosis inferior to the internal ring are now imbricated and sutured to the newly formed floor in Hesselbach's triangle, using interrupted sutures of No. 000 silk (Figs. 5 and 6). This step completes a four-layer repair in Hesselbach's area.

The new external inguinal ring is then formed three-fourths of an inch (1.9 cm.) inferior to the internal inguinal ring by suturing the divided leaves of the external oblique aponeurosis above the cord. The operation is completed by reapproximating the cut leaves of the external oblique aponeurosis above the cord, using interrupted sutures of No. 000 silk (Fig. 6). The superficial fascia is closed over the cord with interrupted No. 0000 silk and the skin with mattress and interrupted No. 000 silk.

In this operation an aponeurosis-to-aponeurosis repair is accomplished. The only layer in which sutures are placed in muscle is the first layer, imbricating the transversalis fascia and muscle.

Three hundred eighty-five, or 59.9%, of the hernias were of the indirect type; 114, or 17.7%, were direct; 136, or 21.4%, were both direct and indirect, and 7, or 1.0%, were of the sliding type (Table 2).

The hernias were divided almost evenly between sides (Table 3).

In addition to the repair of the hernia, 69 other surgical procedures were performed in 66, or 10.2%, of the patients (Table 4).

There were 99 postoperative complications, an incidence of 15.4%. Twenty, or 20.8%, occurred in the wound; 12 were infections, and 8 were hematomas. Twenty-five, or 25.2%, were pulmonary complications, of which 15 were atelectasis and/or pneumonia, 9 were upper respiratory infections, and 1 was an embolism. In 3 patients thrombophlebitis developed, in 7 ileus, and in 36 urinary retention.

TABLE 3.—*Location of Hernia*

Side	Number	Per Cent
Right	349	54.3
Left	293	45.7

TABLE 4.—*Operations in Addition to Hernioplasty*

Type	Number
Appendectomy	3
Epigastric hernioplasty	1
Hydrocelectomy	16
Lipoma of cord, excision	15
Orchidectomy	4
Spermatocelectomy	6
Varicocelectomy	24
Total	69

TABLE 5.—*Postoperative Complications*

Type	Group A 116 Patients Ambulatory 14th Postoperative Day	Group B 247 Patients Ambulatory 7th Postoperative Day	Group C 201 Patients Ambulatory 1st Postoperative Day	Totals, 564 Patients
Pulmonary				
Atelectasis and/or pneumonia	8	4	3	15
Upper respiratory infection	3	3	3	9
Embolism	0	1	0	1
Wound				
Hematoma	1	5	2	8
Infection	4	6	2	12
Urinary retention	5	29	2	36
Ileus	3	4	0	7
Thrombophlebitis	2	0	1	3
Miscellaneous	1	3	4	8
Totals and percentage	27 (23.2)	55 (22.2)	17 (8.4)	99 (17.5)

These complications occurred less frequently in the group of patients ambulatory on the first postoperative day, as compared with the group ambulatory on the 7th and 14th days. These three groups are about equal in number and large enough to be statistically significant (Table 5). The division of the patients into groups will be discussed more fully in relation to follow-up analyses in another portion of this article.

There was one postoperative death, a mortality of 0.15%. The death occurred in a 42-year-old white man on the 10th day as a result of peritonitis secondary to perforation of the ascending colon, shock, and pulmonary edema. The patient

underwent a right inguinal hernioplasty, after which he became markedly distended. A cecostomy, closure of a perforation of the ascending colon, and drainage of the peritoneal cavity were accomplished.

RESULTS

Of the 564 patients operated on, 482, or 85.4%, were followed for a period of one to four years. However, in 384, or 79.6%, of this group, the follow-up period was over two years. Four hundred thirty-six were followed by questionnaire and 46 by examination at this hospital. It appears from a review of the literature that the majority of recurrences take place during the first two years.[5] In view of this, we are of the opinion that the analysis of our results can be of definite statistical value.

There were seven recurrences, or a recurrence rate of 1.4%, in the group in which a follow-up was obtained. On the basis of operative procedures followed (542), the recurrence rate was 1.29%. Recurrence took place in two patients ambulatory on the 13th and 15th postoperative days, in two ambulatory on the seventh postoperative day, and in three ambulatory on the first postoperative day. The operations were performed by five different surgeons. The recurrences developed in three cases within one year, in three within two years, and in one after three years. In two cases the patients were over 45 years of age: one had a disabling rheumatoid arthritis and pulmonary silicosis, and another had pulmonary changes with an associated chronic cough. One of these patients returned to work on the 10th postoperative day as a truck driver. In two other cases severe coughs also developed postoperatively. In one case the cough was due to chronic bronchitis, and in the other it was the result of an acute upper respiratory infection which developed immediately after surgery (Table 6).

This series of patients was divided into three groups for statistical evaluation to compare the effects of early and late ambulation (Tables 6 and 7). In Group A were 116 patients, representing 125 operations, ambulatory on the 14th postoperative day. Of this group, 98 patients, representing 105 operations, were followed from three to four years. There were a total of 27 complications and a recurrence rate of 1.9%, or two recurrences. In Group B there were 247 patients, representing 281 hernioplasties, ambulatory on the 7th postoperative day. In this group 209 patients, with 235 (43%) operations, were followed for two to three years. Fifty-five complications devloped and two recurrences took place, an incidence of 0.85%. In Group C there were 201 patients, with 236 operations, ambulatory on the first postoperative day. In this group 175 patients, on whom 202 (31%) hernioplasties were performed, were followed for one to two years. Seventeen postoperative complications developed. Recurrences occurred in three patients, a rate of 1.4%.

5. Clear, J. J.: Ten Year Statistical Study of Inguinal Hernias: A Comparison of the Rate of Recurrence Following Repair by Halsted I and Other Operations, A. M. A. Arch. Surg. **62**:70 (Jan.) 1951. Edwards, H.: Discussion on Hernia, Proc. Roy. Soc. Med. **36**:185, 1943. Estes, W. L., Jr.: Surgical Treatment of Inguinal Hernia, Postgrad. Med. **7**:313, 1950. Gibson, C. L., and Felter, R. K.: End-Results of Inguinal Hernia Operations, Ann. Surg. **92**:744, 1930. Marble, H. C.: Recurrent Hernia, New England J. Med. **209**:574, 1933. Shelley, H. J.: Recurrent Inguinal Hernias: Study of 282 Hernias and 268 Repairs, Arch. Surg. **41**:1437 (Dec.) 1940. Skinner and Duncan.[4]

TABLE 6.—*Analysis of Seven Recurrences*

Age	Primary Hernia Type	Recurrence After Primary Repair in Months	Type of Recurrence	Day of Ambulation	Physical Findings	Period of Convalescence	Type of Work	Comment
27	Direct, right	17	Indirect, right	7	Not remarkable	42 days	Clerical	Uneventful postoperative course
31	Small indirect, right	37	Indirect, right	13	Amebic abscess of liver, 1946 and 1947	40 days	Locomotive fireman	Uneventful postoperative course
31	Indirect, left	16	Indirect, left	1	Weight, 190 lb.; acute upper respiratory infection postoperatively	60 days	Farming	Chronic cough and chronic sinusitis, postoperative
48	Indirect, left, scrotal; incarcerated omentum	11	Indirect, left	15	Diffuse silicosis, advanced rheumatoid arthritis	Unable to work because of arthritis and deformity		Thin, emaciated, chronic cough
55	Indirect, right, scrotal	7	Indirect, right, sliding	1	Pulmonary emphysema; arthritis, hypertrophic, of spine	10 days	Truck driver	Uneventful postoperative course
56	Indirect, bilateral	11	Indirect, right	1	Not remarkable	21 days	Cashier	Epididymitis, right, 4th postoperative day
59	Indirect and direct, right	22	Indirect, right	7	Fibrosis, right upper lobe; inactive tuberculosis	Unemployed for years		Poorly nourished, chronic bronchitis with severe cough

Table 7 summarizes the results and complications occurring in the entire series under the three groups described above.

Since the majority of current reports in the literature reveal that 80 to 90% of recurrences following the primary repair for inguinal hernias occur during the first two years, we are of the opinion that the study of our series and a report of our findings at this time is valid, for in 70% of our series the patients were followed over a two-year period.

The recurrence rate was low in all three groups studied. Early ambulation effected a marked reduction in the postoperative complications but did not increase the recurrence rate. In three of the five recurrences, the basic repair might have remained intact if the coughing paroxysms could have been controlled in the

TABLE 7.—*Summary of Results and Complications by Groups*

Groups	Number of Patients	Number of Operations	Based on Number of Operations		
			Follow-up, %	Recurrences, %	Complications, %
A					
Ambulatory 14th postoperative day, followed 3 to 4 years.....	116	125	84.0	1.9	21.6
B					
Ambulatory 7th postoperative day, followed 2 to 3 years.....	247	281	83.6	0.85	19.5
C					
Ambulatory 1st postoperative day, followed 1 to 2 years.....	201	236	85.5	1.4	7.2
Totals.....	564	642	84.3	1.29	15.4

patients during the postoperative period. In two of these cases the patients had chronic pulmonary disease, and in the third case an acute upper respiratory infection developed immediately after the hernioplasty. The fourth patient returned to heavy work as a truck driver on the 10th postoperative day, which we feel is valid reason for his hernia repair to break down and result in a recurrence. In view of this, it may be assumed that the recurrences in four of the seven cases might not have taken place under more favorable circumstances.

Our patients were instructed to refrain from heavy lifting, straining, or athletics for a period of six to eight weeks postoperatively. They were permitted to return to a sedentary type of work at the end of two weeks.

SUMMARY AND CONCLUSIONS

A statistical analysis of the results of 642 primary inguinal hernioplasties performed on 564 unselected male patients is presented. A follow-up for a period of one to four years was obtained in 85.4% of this series.

There were seven recurrences, or a recurrence rate of 1.4%. The recurrence rates in the groups of patients ambulatory on the 1st, 7th, and 14th days were 1.7, 0.95, and 2.04%, respectively. The recurrence rate based on the total number of operations performed was 1.29%. Each group was sufficiently large to be statistically significant, so that from these studies early ambulation did not appear to increase the recurrence rate.

A combined modified Bassini, Halsted I, and Andrews operation was performed, using either cotton or silk sutures. A description with diagrammatic illustrations is presented, depicting the important features of this operation.

There were 99 postoperative complications, of which 20% involved the wound. There was a definite reduction in the incidence of complications dependent on the day of ambulation. In the series of cases in which the patients were ambulatory on the first postoperative day the incidence of complications was 7.2%, as compared with an incidence of 19.5 and 21.6% for the group of patients ambulatory on the 7th and 14th postoperative days.

It appears from these studies that early ambulation effected a marked reduction in the postoperative complications, particularly those of the respiratory, gastrointestinal, and urinary tracts.

Case Reports

IDIOPATHIC SPONTANEOUS SEGMENTAL INFARCTION OF THE OMENTUM

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THE OCCURRENCE of spontaneous idiopathic infarction of a segment of the greater omentum would appear to be extremely rare. A review of the surgical literature reveals only 17 previously reported authentic cases in which spontaneous infarction occurred without evidence of other contributory intraperitoneal pathologic changes. This condition is not to be confused with primary torsion of the omentum or with strangulation or torsion of the omentum due to herniation or adhesions. The first authentic case report is generally accredited to Johnson, who reported a case in 1932, although his case was complicated by the fact that the tip of the omentum was adherent to a scar resulting from a previous herniorrhaphy. Pines and Rabinovitch reported six cases in 1940, and Joss and Pratt in 1946 reported a personal case in addition to the 12 cases which they could find in the literature. Seley in 1951 reports a case, stating that he was able to find only 16 authentic cases in the previous literature. As suggested by several authors, this paucity of reported cases is probably not a true indication of the incidence of the condition, since many cases probably remain undiagnosed even at the operating table.

The correct diagnosis has not been made or, indeed, suspected preoperatively in any of the reported cases. In 15 of the 17 cases a preoperative diagnosis of acute appendicitis was made, one lesion was mistaken for a perforated peptic ulcer, and the remaining one was thought to be either a perforated ulcer or acute appendicitis. So far as we can tell, the case here reported is the first in which the clinical manifestations of spontaneous omental infarction so closely simulated those of acute cholecystitis that the patient was operated on with that diagnosis in mind.

CLINICAL FEATURES

There are no distinctive clinical features of this condition. In general, the symptoms, signs, and laboratory findings simulate those of acute appendicitis and those certainly cover a wide range of possibilities. The reported cases cover an age span of 9 to 63 years, with apparently equal sex distribution. The usual mild leucocytosis and slight increase of pulse and temperature are not of diagnostic significance. If there be any constant clinical picture, it is one of abdominal pain and tenderness, usually in the right lower quadrant. Pines and Rabinovitch first pointed out the disproportion between abdominal tenderness, duration of symptoms, and abdominal rigidity. There is usually marked abdominal tenderness, frequently with skin hyperesthesia but without the degree of muscle rigidity one would expect. This is due to the fact that the area of peritoneal irritation is localized by a small segment of infarcted omentum plastered against the adjacent parietal peritoneum.

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The patient herein reported on did not appear acutely ill, showing a marked degree of well-being with only minimal gastrointestinal complaints, all of these being inconsistent with the degree of localized abdominal tenderness and hyperesthesia. This appears to have been true in most of the other reported cases.

In all the reported cases recovery was uneventful after removal of the infarcted segment of omentum. Cagney and Milroy reported recovery in a case in which the involved segment of infarcted omentum was not removed. Undoubtedly many cases of this condition occur with spontaneous recovery although surgical excision is indicated to prevent possible troublesome adhesions at a later date. In any event, expectant treatment of an acute abdomen with this diagnosis in mind would be extremely hazardous because of the impossibility of differentiating this condition from the many more frequent conditions demanding early surgical intervention.

PATHOGENESIS

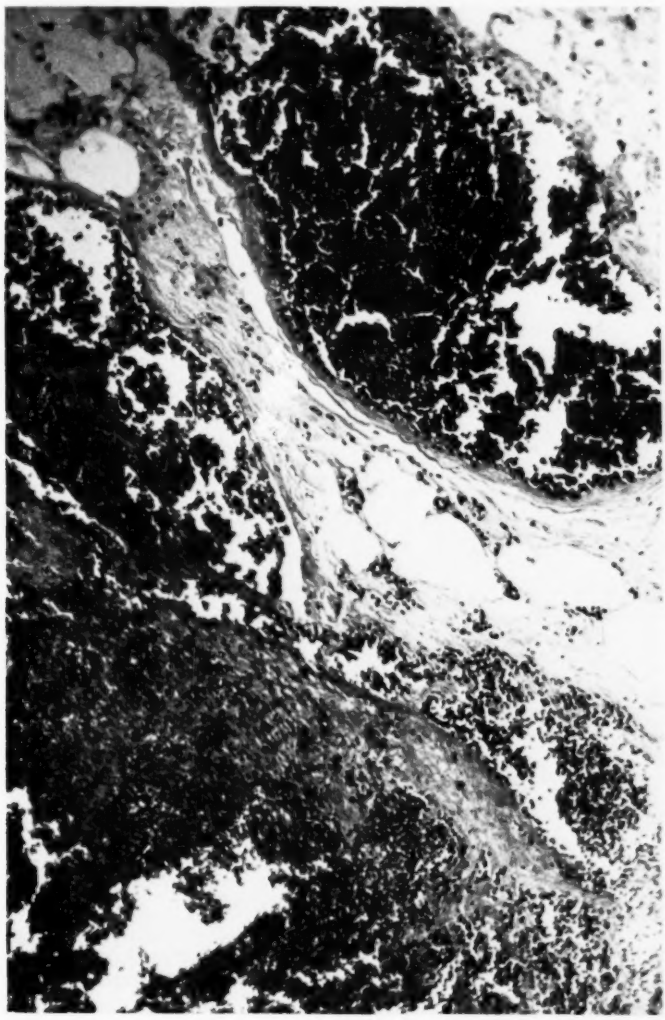
At operation the usual picture is that of a firm red to purplish black mass of hemorrhagic necrotic omentum 3 to 5 cm. in diameter adherent to the anterior parietal peritoneum. There may or may not be present a small amount of serosanguineous fluid in the peritoneal cavity. The microscopic picture consists in congestion and thrombosis of the venous channels, with hemorrhagic extravasation into the omental fat. There is also a mild inflammatory reaction in which the exudate consists of monocytes, polymorphonuclear leucocytes, and plasma cells. There may be numerous lipophages present.

There has been considerable speculation on the possible etiology or mechanism by which spontaneous omental infarction might occur. Pines and Rabinovitch advanced the theory that venous thrombosis occurs consequent to stretching of the omental veins secondary to some trauma with subsequent omental infarction. Totten further theorizes that the strain on the thin-walled veins between the stomach and the omentum is increased at the time of vascular congestion following the ingestion of a full meal and that during this period any additional abdominal tension such as straining, coughing, sneezing, or lifting might result in rupture of a dependent vein, with hemorrhagic extravasation and secondary thrombosis. Since the onset of symptoms is somewhat gradual, it is difficult to associate definitely any possible cause such as heavy lifting or a large meal as a positive factor. However, one of Totten's patients gave a history of handling boxes weighing 120 lb. (54.4 kg.) each shortly after the noon meal and just prior to the onset of abdominal pain, while MacKenzie and King reported a case with the onset of symptoms occurring shortly after the ingestion of 1 lb. (0.5 kg.) of cheese. Seley reports a case occurring in a patient with polycythemia vera.

REPORT OF CASE

R. H. B., a 41-year-old white man, was admitted to the hospital on May 28, 1950, complaining of abdominal pain. The onset of symptoms had occurred approximately 48 hours prior to his admission, when the patient noticed pain in the right upper quadrant of the abdomen shortly after rising in the morning. The pain gradually increased in intensity during that day. On the day of admission it was considerably worse and was described as being steady, with occasional exacerbation of the sharp knife-like pain. There had been no nausea or vomiting. Stools and urine had been normal in color and frequency. The patient reported that during the past year he had had three previous similar attacks although they had been mild in nature and he had not been forced to be absent from work. There was a vague history of intolerance to fatty foods but no history of jaundice. The patient had been under the care of a psychiatrist during the past

several years because of nervousness. The only other possible contributory past history was that of having passed a urinary calculus on the right side seven years previously and again of having passed a stone on the same side approximately six months prior to his admission. There were no urinary symptoms accompanying the present episode. There was no history of previous surgery.



Photomicrograph showing congestion and thrombosis of venous channels with hemorrhagic extravasation into the omental fat. × 200.

Physical Examination.—Examination revealed a well nourished, moderately obese man who did not appear acutely ill. The temperature was normal. Positive physical findings were limited to the abdomen, which was soft and nontender except in the right upper quadrant, where there were marked tenderness and skin hyperesthesia with a moderate amount of rigidity. There was slight referred rebound tenderness to the right upper quadrant. The maximum point of tenderness was approximately 2 in. (5 cm.) to the right of the midline and 1 in. (2.5 cm.) below the costal margin.

Laboratory work on the patient's admission revealed a white blood count of 10,800 with 78% polymorphonuclears. Numerous white blood cells were reported in the urine. X-ray examination of the chest revealed the right dome of the diaphragm to be slightly irregular. An abdominal flat plate, plate of the kidney, ureter, and bladder and an intravenous pyelogram showed no abnormalities. Approximately eight hours after his admission the patient was taken to surgery for exploration. The preoperative diagnosis was acute cholecystitis.

Operation.—The abdomen was entered through a right upper rectus incision. There was a small amount of amber-colored fluid in the peritoneal cavity. The gall bladder and appendix were found to be normal. A segment of the lower margin of the right portion of the greater omentum was found to be thickened, firm, indurated, and edematous and to have a purplish gray color. This segment was approximately 10 cm. by 3 cm. in size. It was adherent to the anterior parietal peritoneum, and there was a loop of ileum adherent to the medial portion of the infarcted segment. The involved segment was separated from the peritoneum and the adherent loop of bowel with relative ease and excised, the amputated portion being ligated.

Microscopic Observations.—Examination of the excised specimen showed congestion and thrombosis of the venous channels, with hemorrhagic extravasation into the omental fat (Fig.). The surface showed a mild inflammatory reaction with mixed exudate consisting of monocytes, polymorphonuclear leucocytes and plasma cells.

The postoperative course was uneventful. The sutures were removed on the sixth postoperative day, and the patient was discharged asymptomatic. Follow-up examination one year subsequent to operation revealed the patient to have been asymptomatic during that time.

SUMMARY

A case of primary idiopathic segmental infarction of the greater omentum is presented, along with a brief review of the literature pertaining to this rare condition.

This case is of interest not only in being the 18th reported case in the literature but also in being the first closely simulating acute cholecystitis in its clinical manifestations.

This condition is undoubtedly commoner than is indicated by the paucity of reported cases and should be looked for when exploration in an acute abdominal condition fails to reveal the expected findings.

BIBLIOGRAPHY

Cagney, M. S., and Milroy, G.: Idiopathic Infarction of the Greater Omentum, Brit. J. Surg. **35**:95, 1947.

Eger, S. A., and Barto, R. E., Jr.: Primary Idiopathic Segmental Infarction of the Greater Omentum, Am. J. Surg. **78**:518, 1949.

Graham, J. A., and Levinson, S. A.: Omental Apoplexy: Idiopathic Segmented Infarction of the Greater Omentum, Am. J. Digest Dis. **17**:114, 1950.

Harris, F. I.; Diller, T., and Marcus, S. A.: Hemorrhagic Infarction of the Greater Omentum Simulating Acute Appendicitis: Report of 2 Cases, Surgery **23**:206, 1948.

Hines, L. E.: Hemorrhagic Infarction of the Greater Omentum, Illinois M. J. **66**:166, 1934.

Johnson, A. H.: The Greater Omentum and Omental Thrombosis, Northwest Med. **31**:285, 1932.

Joss, C. S., and Pratt, J. H.: Primary Idiopathic Segmental Infarction of the Greater Omentum, Minnesota Med. **31**:996, 1948.

MacKenzie, W. C., and Small, J.: Primary Idiopathic Segmental Infarction of the Greater Omentum, Canad. M. A. J. **55**:144, 1946.

Manfredi, D. H.: Omental Segmental Infarction in Infancy: Report of Case, Arch. Pediat. **67**:247, 1950.

Pines, B., and Rabinovitch, J.: Idiopathic Segmental Infarction of the Greater Omentum, Surg., Gynec. & Obst. **71**:80, 1940.

Selev, G. P.: Primary Idiopathic Segmental Hemorrhagic Infarction of the Greater Omentum, J. Mt. Sinai Hosp. **17**:523, 1951.

Totten, H. P.: Primary Idiopathic Segmental Infarction of the Greater Omentum, Am. J. Surg. **56**:676, 1942.

SCIATIC NOTCH HERNIA

Report of a Case and Description of a New Operative Approach

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SCIATIC notch hernia is a rare condition for which a correct preoperative diagnosis is seldom made. Watson [1] in his excellent monograph reports on 35 cases collected from the literature. Lawson [2] in 1948 reported another case and cited two Russian authors [3] who have reported on 25 cases. Whether the latter authors are reporting the same cases as those reported by Watson is difficult to determine.

Of the 35 patients reported on by Watson, 13 were treated by operation, 11 of whom recovered. Nine patients had reducible hernias which were treated with bandages. Eight such patients were found at autopsy, in six of whom strangulation had been the cause of death. The case reported by Lawson was diagnosed as a case of intestinal obstruction, treated surgically by an exploratory laparotomy, with repair of the hernia through the intra-abdominal route.

The surgical approach used by most of the writers has been intra-abdominal. A direct approach through the gluteus muscle has been described, but this is condemned because of the vascularity plus the possibility of injury to the sciatic nerve.

REPORT OF A CASE

K. L. was a 22-mo.-old white boy whose mother stated that she first noticed a mass in his right buttock four or five weeks before he was seen by us on Sept. 19, 1950. She first became aware of the mass while bathing the child. It was about the size of her fingertip when first seen and became progressively larger with time. She was also aware of the fact that the mass was always smaller in the morning and seemed to be larger by evening.

The child had never received any medication in oil into the buttocks. The review of the systems was essentially noncontributory. He had no serious medical illness, had undergone no previous operations, and had received the usual immunization against contagious diseases. The family history revealed no evidence of carcinoma, tuberculosis or diabetes.

Physical examination revealed nothing abnormal except for an undescended left testicle and a mass in the right buttock measuring 6 cm. in greatest diameter. The mass was tense and irreducible. The child cried throughout the physical examination, and therefore the reducibility could not be accurately determined. A preoperative diagnosis of sciatic hernia, myxoma, or lipoma was made.

The preoperative laboratory study revealed normal urine. The hemoglobin content was 10.2 gm. per 100 cc., or 60.5%. The white blood cell count was 11,600 per cubic millimeter. The differential count revealed 27% neutrophils, of which 1% were stab forms and 26% were

1. Watson, L. F.: Hernia, ed. 3, St. Louis, C. V. Mosby Company, 1948.
2. Lawson, R.: Sciatic Hernia, Canad. M. A. J. **59**:265-267 (Sept.) 1948.
3. Krynor and Zigberman, cited by Lawson.[2]

segmented, and 73% lymphocytes. The clotting time was 5 min. 45 sec., and the bleeding time was 2 min.

The operative procedure was carried out on Sept. 29, 1950, at the Children's Hospital of the East Bay, a general inhalation anesthesia being used. The mass in the right gluteal region, which measured 4 by 2 cm. preoperatively and could be readily palpated, disappeared as soon as the patient became relaxed with the anesthesia. The patient was placed on his left side on the operating table, after he was anesthetized. The position on the table was such that the upper outer quadrant of the right buttock was uppermost. This position was maintained with sand bags and adhesive straps. An incision was made in the right gluteal region. It was started 2 cm. below the posterior-superior iliac spine and was carried laterally in a curve over the greater trochanter, at which point it was swung distally and medially toward the gluteal fold and then down over the posterior thigh for several centimeters. This skin incision resembled a loose question mark. A skin flap was raised, revealing the gluteus maximus muscle. The lateral fascial sheath of this muscle was incised near the insertion of the gluteus maximus, and in that way it was separated from the gluteus medius. The insertion of the gluteus maximus on the linea aspera of the femur was then incised between clamps, allowing the muscle to be reflected medially. This permitted visualization of the gluteus medius as well as of the pyriformis muscle as it crossed over the sciatic notch. The sciatic nerve and the superior and inferior gluteal vessels were exposed.

At this point the hernial sac could not be found. The patient was therefore partially awakened, enough to permit him to strain. With straining, a bulge was seen to appear in the superior sciatic notch. This disappeared as soon as the patient stopped straining. Since the right ureter and the cecum are in this region, it was considered unwise to try to invert the sac blindly. The pyriformis muscle was then approximated to the gluteus medius by means of interrupted No. 60 cotton sutures. This closed the superior sciatic space, leaving room enough only for the superior gluteal vessels and nerve to come through. The gluteus maximus muscle was then sutured at its insertion with the same type of suture, and the lateral fascia was closed with interrupted sutures. The subcutaneous tissues were closed with interrupted No. 60 cotton sutures, and the skin was closed with a No. 60 cotton locking suture. All ligatures were 000 plain surgical gut.

The patient withstood the procedure well. Postoperatively, he required no special attention. He was permitted to walk as soon as he had the inclination, which was on his first postoperative day. He left the hospital on the fifth postoperative day. When he was last seen, on March 27, 1951, after a period of six months, there was slight hypertrophy of the skin scar but no evidence of recurrence of the mass.

COMMENT

There are three points which we should like to emphasize. First, any mass in the gluteal region, particularly in the upper outer quadrant, may be the result of a sciatic hernia. Second, if such a hernia is suspected, the repair should be carried out before an obstruction or strangulation occurs. Third, the usual approach through the gluteus maximus muscle body enters through the most vascular portion of this muscle, thereby creating certain technical difficulties. The approach described herein is relatively simple, because it utilizes the avascular portions of the muscle and yet gives excellent exposure.

The intra-abdominal route is the one of choice in cases in which obstruction and/or strangulation occurs. The posterior approach, however, permits the closing of the sac and the repairing of the defect, which are the criteria for successful repair of hernias in any part of the body.

SUMMARY

A brief review of the literature on sciatic notch hernia is presented. A case is described in which a preoperative diagnosis of sciatic hernia was entertained. A new operative approach is reported.

447 Twenty-Ninth Street.

LATERAL FEMORAL HERNIA AND STRANGULATED MECKEL'S DIVERTICULUM

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THE MOST frequent cause of mechanical obstruction of the small intestine is incarceration or strangulation in an external hernia. The occurrence of incarceration or strangulation of Meckel's diverticulum within an external hernia, with or without intestinal obstruction, is a rare finding and still more rare within a femoral hernia. The infrequency of this surgical emergency is illustrated in Table 1. Twenty-eight cases have been reported to date.[1]

A review of the literature failed to reveal a case of Meckel's diverticulum strangulated in a femoral hernia of the lateral type, i. e., a herniation lateral to the neurovascular bundle. In itself, this type of femoral hernia is very infrequent. According to Watson,[2] the firm attachment of the iliac and transversalis fasciae to the outer half of the inguinal ligament and the resistance offered by the psoas and iliacus muscles and the iliac fascia account for the rarity of this lateral type of femoral hernia. A patient with lateral femoral hernia and with strangulation of Meckel's diverticulum within it was recently encountered at City Hospital, Cleveland, and the following is a description of her case history:

E. B., a 72-year-old white woman, was admitted to City Hospital, Cleveland, on Nov. 2, 1950. Her present illness began seven days prior to her admission with pain in the right groin.

From the Department of Surgery, Western Reserve School of Medicine, City Hospital.

1. (*a*) Pabst, F.: Ein Meckelsches Divertikel in einer Hernia interparietalis inguinalis incarcerata dextra, Beitr. klin. Chir. **69**:646, 1910. (*b*) Burianek, B., cited by Sweet, R. H.: Incarceration of a Meckel's Diverticulum in a Femoral Hernia: Report of Case with Review of Literature, New England J. Med. **202**:997, 1930. (*c*) Harf, A.: Einklemmung des Meckelschen Divertikels in einer Schenkelhernia, Deutsche med. Wchnschr. **14**:881, 1919. (*d*) Ludbrook, S. L.: Unusual Complications in 2 Cases of Femoral Hernia, Brit. J. Surg. **10**:297, 1922. (*e*) Littler, R. M.: Meckel's Diverticulum Strangulated in a Femoral Hernia, Brit. M. J. **1**:517, 1924. (*f*) Harrington, S. W.: Strangulated Meckel's Diverticulum in Right Femoral Canal, Surg. Clin. North America **6**:1188, 1926. (*g*) Sweet, R. H.: Incarceration of a Meckel's Diverticulum in a Femoral Hernia: Report of Case with Review of Literature, New England J. Med. **202**:997, 1930. (*h*) Donati, G. S.: Strozzamento in ernia crurale destra, del diverticolo di Meckel, Policlinico (sez chir.) **38**:278, 1931. (*i*) Quiri, A.: Occlusione da diverticolo di Meckel in un sacco di ernia crurale, Arch. ital. chir. **54**:16, 1938. (*j*) Strohl, E. L., and McArthur, S. W.: Incarcerated Meckel's Diverticulum in Femoral Hernia, Arch. Surg. **38**:783, 1939. (*k*) Ringo, R. E., and Charlton, M. R.: Meckel's Diverticulum and Littre's Hernia: Report of a Case, Northwest. Med. **39**:60, 1940. (*l*) Marti, T., and Cottet, P.: Historie d'un diverticule de Meckel incarcéré et perforé dans une hernie fémorale gauche, Rev. med. Suisse Rom. **62**:357, 1942. (*m*) Patterson, F. M. S.: Incarceration of Meckel's Diverticulum in a Femoral Hernia: Report of a Case, North Carolina M. J. **7**:59, 1946.

2. Watson, L. F.: Hernia, ed. 3, St. Louis, C. V. Mosby Company, 1948, p. 299.

The pain was dull and persistent, without radiation or colic. No nausea or vomiting had occurred. Her bowels moved after catharsis two days before admission, but except for this she had been obstipated for five days. She had passed flatus throughout her illness, however, and had noted no bloody or tarry stools. The patient had not noted swelling in the right groin. She had experienced no abdominal pain and had noticed no abdominal distention.

Her past history revealed the presence of severe rheumatoid arthritis for 18 years, and she had undergone a left midthigh amputation 10 years previously for ischemic necrosis of the foot secondary to arterial thrombosis.

Physical examination revealed a chronically, not acutely, ill white woman, aged 72, whose body was distorted by the ravages of rheumatoid arthritis. Her temperature was 37.8 C. (100 F.), the pulse rate was 100 per minute, and the respiratory rate was 20 per minute. Her blood pressure was 140/70. The lungs were normal except for bilateral fine basilar rales. The heart was normal in size and rhythm. No murmurs were heard. There was a firm, moderately tender mass in the right groin below the inguinal ligament, about 8 by 5 cm. in size, which was lateral to the position occupied by the usual type of femoral hernia. Peristaltic sounds were present over the mass. The abdomen was scaphoid. No abnormal tympany was present to percussion over the abdomen. There was slight to moderate tenderness in the right lower quadrant. No rebound tenderness was found. No masses were palpated in the abdomen.

TABLE 1.—*Reports of Incarcerated or Strangulated Meckel's Diverticulum in Femoral Hernia*

Author	Year	No.
Pabst *	1910	15
Burianek	1913	1
von Harf	1919	1
Ludbrook	1922	1
Littler	1924	1
Harrington	1926	1
Sweet	1930	1
Donati	1931	1
Quirl	1938	1
Strohl and McArthur	1939	2
Ringo and Charlton	1940	1
Marti and Cottet	1942	1
Patterson	1946	1

* Even after repeated translation of the collective review by Pabst [1a] in 1910, confusion persists. This author used the terms "Cruralhernie" and "Schenkelhernie" interchangeably. Interpretation of these words is not constant. He states that of the 24 "Cruralhernien" reviewed, there were 17 incarcerated and 7 free. He continues: ". . . of the 'Schenkeldivertikelhernien' there were fifteen incarcerated and six free." Further confusion results from the author's admission that his data are definite in only 90 of the 123 cases of hernias associated with Meckel's diverticulum which he had reviewed from the literature.

Peristalsis was active. Pelvic and rectal examinations revealed no abnormalities. Normal brown stool was present in the rectum. Examination for occult blood was not done.

Laboratory data were as follows:

The urine was yellow and acid in reaction, with a specific gravity of 1.014. Microscopic examination gave negative results. No albumin or sugar was present. The hemoglobin was 15 gm. per 100 cc. The red blood cell count was 5,200,000. The white blood cell count was 15,800, with a differential count of 84% polymorphonuclear leucocytes, 15% lymphocytes, and 1% eosinophils. The platelets appeared normal.

The preoperative diagnosis was incarcerated right femoral hernia.

Herniorrhaphy was done under drop ether anesthesia. The classical incision was made over the right inguinal canal. The inferior flap of skin and subcutaneous tissue was reflected laterally and distally over the inguinal ligament. Examination of the area over the pectineus muscle medial to the femoral sheath revealed no evidence of hernia. The transversalis fascia was opened from the internal inguinal ring to the pubic tubercle. This fascia was found to be applied firmly to the ileopectineal line, and no weakness was present in the area through which the common variety of femoral hernia protrudes. The femoral sheath and its contents were again carefully identified. Laterally, in a space caudad to the inguinal ligament, a gas-filled sac was encountered. With gentle palpation, gas could be extruded from the sac. It would

return on release of pressure. Swelling and crepitation were also evident beneath the origins of the internal oblique and transversalis muscles from the lateral half of the inguinal ligament. During examination of the hernial sac there was a sudden reduction in its size. In the process of dissecting the fundus of the sac, it was inadvertently entered through a 1 cm. rent, and feculent, malodorous pus escaped into the wound. The sac was thick-walled, and its internal lining was acutely inflamed. The sac was closed in two layers, and a search was made for a gangrenous intestinal segment through a muscle-splitting right lower quadrant incision. Free pus was encountered within the peritoneal cavity. The appendix and cecum were normal. The small bowel was entirely normal except for a gangrenous Meckel's diverticulum located approximately 2 ft. (60 cm.) from the ileocecal valve. The diverticulum was 4 by 2 cm. in size. There was a definite ring of constriction around its middle, and the distal half was gangrenous and necrotic. Its neck was 1 cm. in diameter at its junction with the ileum. The diverticulum wes resected, and the longitudinal effect in the ileum was repaired transversely in two layers. The hernia was repaired by the McVay [3] technique. The abdomen was closed without drainage. A Penrose drain was placed in the bed of the hernial sac on the thigh and exteriorized through a stab wound.

The patient's postoperative course was uneventful, and she was discharged on her 11th hospital day. Follow-up at the time of this report reveals that she is doing well.

The pathological report was "Meckel's diverticulum showing acute and chronic inflammation with perforation and peritonitis."

COMMENT

One may reasonably question whether or not the case reported here actually represents strangulated Meckel's diverticulum within a femoral hernia of the lateral or external type. Such is believed to be the case, however, because at the time of operation, with relaxation of the patient, there was a sudden reduction in the size of the hernial sac contents and, when opened, the lining of the sac suggested contact with an inflamed gangrenous organ. Furthermore, the diverticulum was grossly constricted about its middle, suggesting incarceration at this point by the neck of the hernial sac. There was no other area in the bowel suggesting incarceration or strangulation.

Femoral hernia constitutes 2.5% of all hernias in both sexes and 97% of all hernias in women.[2] The common type of femoral hernia protrudes through a weakness in the transversalis fascia just above its attachment to the ileopectineal line and lies on the pectineus muscle medial to the femoral sheath. The ring is bounded by the ileopectineal line posteriorly, the femoral sheath laterally, the inguinal ligament anteriorly, and the lacunar ligament medially. Rare varieties of femoral hernia are: (1) external femoral hernia or Hesselbach's hernia (lateral type of femoral hernia), (2) hernia through the lacunar ligament, or Laugier's hernia, (3) pectineal hernia, or Cloquet's hernia, (4) retrovascular hernia, (5) prevascular hernia, and (6) multilocular hernia. These varieties of femoral hernia are encountered so infrequently that no percentage figures on their incidence are available.

Meckel's diverticulum is not an uncommon finding, occurring in 1 to 2% of the general population, and about one-tenth of the surgical complications of Meckel's diverticulum involve incarceration or strangulation in hernias 4 (Table 2).

3. McVay, C. B., and Anson, B. J.: Inguinal and Femoral Hernioplasty, Surg. Gynec. & Obst. **88**:473, 1949.

4. Moses, W. R.: Meckel's Diverticulum: Report of 2 Unusual Cases, New England J. Med. **237**:118, 1947.

While strangulation of the intestine is common in femoral hernia, it is rare to find a strangulated Meckel's diverticulum within a femoral hernia (Table 1).

Approximately 50% of the cases of Meckel's diverticulum encountered in external hernias have involved inguinal hernias. Twenty-five to 30% have occurred in umbilical hernias, and the vast majority of these patients have been newborn infants.[5] The remaining 20 to 25% of the cases reported have occurred in femoral hernias.[6] The incidence is greater in women than in men and is three times greater on the right side than on the left.

It has been pointed out by Donati [1h] and by Keeley [5] that the usual signs and symptoms of intestinal strangulation may not be present with a strangulated Meckel's diverticulum in a femoral hernia. Local symptoms may be marked, but the general systemic reaction is often not alarming. Such was the case with the patient reported above. She had been seen by a qualified surgeon two days prior to her

TABLE 2.—*Complications of Meckel's Diverticulum* [4]

1.	Hemorrhage	30.9%
2.	Intestinal obstruction	23.8%
3.	Perforation	13.8%
4.	Littre's hernia	11.7%
5.	Simple diverticulitis	10.3%
6.	Umbilical fistula	2.2%
7.	Foreign body involvement	1.8%
8.	Umbilical polyp	1.5%
9.	Cancer	0.62%
10.	Tuberculosis	0.56%
11.	Typhoid perforation	0.37%
12.	Omphalocele	0.18%
13.	Traumatic perforation	0.18%

admission to the hospital. He noted the mass in her right groin, but because of its lateral position and the absence of abdominal findings, he thought it to be an abscess. Even on her admission the patient did not appear seriously ill. This lack of general systemic reaction may lead one to suspect the condition, but for practical purposes the diagnosis of strangulated or incarcerated Meckel's diverticulum in a femoral hernia, or in any type of hernia, can be made only at operation.

SUMMARY

Incarceration or strangulation of Meckel's diverticulum in a femoral hernia is a rare entity. Twenty-eight cases had been reported to date. The present case brings the total to 29. The condition has occurred oftener in females than in males. It has a predilection for the right side. No previous case of strangulated Meckel's diverticulum in the lateral type of femoral hernia has been reported.

5. Keeley, J. L.: Meckel's Diverticulum in Sac of Ventral Incisional Hernia: Report of Case, Wisconsin M. J. **36**:733, 1937. Pabst.[1a]

6. Gray, H. K.: Meckel's Diverticulum in Hernia: Report of a Case, Minnesota Med. **17**:68, 1934. Patterson.[1m]

RESECTION OF AN ANEURYSM OF THE ABDOMINAL AORTA

Reestablishment of the Continuity by a Preserved Human Arterial Graft, with Result After Five Months

CHARLES DUBOST, M.D.
MICHEL ALLARY, M.D.
AND
NICOLAS OECONOMOS, M.D.
PARIS, FRANCE

Mr. Le G., aged 50 years, had an aneurysm of the abdominal aorta revealed by gross disturbances of function, predominantly in the left leg. Abdominal examination showed a large tumor in the left paraumbilical region, pulsating and expansile. The right femoral pulse was diminished and the left absent; oscillations were diminished on the right and absent on the left. One year before he had had a myocardial infarction. The blood Wassermann test was negative. The aortograph (Fig. 1) shows that the beginning of the aneurysm is just below the kidneys and that it extends as far as the bifurcation of the aorta. The left common iliac artery is blocked in its first 5 or 6 cm. The right common iliac artery, although patent, has at its origin two small aneurysmal dilatations. The superior mesenteric and renal arteries, perfectly delineated by the opaque medium, are clearly above the aneurysm. The inferior mesenteric artery, however, is not injected. The left iliac artery seems to receive its blood by the spermatic artery or one of its branches.

Operative Intervention (March 29, 1951, Dr. Dubost).—A left thoracoabdominal incision was made, an extraperitoneal approach being used, and resection of the 11th rib was carried out. Retraction of the peritoneal sac disclosed an enormous aneurysm extending from the origin of the renal arteries to the common iliac arteries. It was decided to attempt its complete removal and to use a graft to reestablish continuity of the arteries.

The operation was carried out in the following stages: Control of the aneurysm was obtained by a clamp placed proximally to it, immediately below the renal arteries. Next, in the region of the iliac arteries, came exposure, isolation, and provisional hemostasis of both external iliac and both internal iliac arteries. Section of both common iliac arteries was performed and then dissection of the aneurysm from below upward. The stripping was troublesome near the common iliac veins and the inferior vena cava, which were adherent in places to the aneurysmal sac, fragments of which had to be left in some places. The lumbar vessels, thrombosed, were sectioned without ligature. The inferior mesenteric artery did not bleed from the proximal cut end but did spurt blood from the peripheral end. The aneurysm, entirely freed, was turned upward and sectioned 2 cm. from the clamp on the aorta.

The cut end of the aorta proximally and the cut end of the right common iliac artery peripherally were trimmed in order to interpose the graft (15 cm. in length and taken from the thoracic aorta of a 20-year-old girl three weeks previously). The superior anastomosis of the aortic graft was carried out with 5/5 silk 0 (Bruneau).

Since we did not have a Y-shaped graft, it was necessary to make an end-to-end anastomosis between the graft and the right common iliac artery (Fig. 2).

The obstruction in the left common iliac artery was removed, and after section of the internal iliac artery, which was itself blocked, it was anastomosed to the side of the graft

From the Department of Surgery, No. 1 Broussais Hospital (Prof. F. d'Allaines), Paris.

This case was previously discussed in *La Semaine des hôpitaux de Paris*, Sept. 18, 1951. Permission to report it here and to reproduce the illustrations has been obtained.

Fig. 1.—Preoperative aortograph. The aneurysm begins 2 or 3 cm. below the renal arteries. Inferiorly, it involves the aortic bifurcation; the right common iliac artery shows at its origin two aneurysmal dilatations, and the left common iliac is obstructed. The inferior mesenteric artery is not delineated.

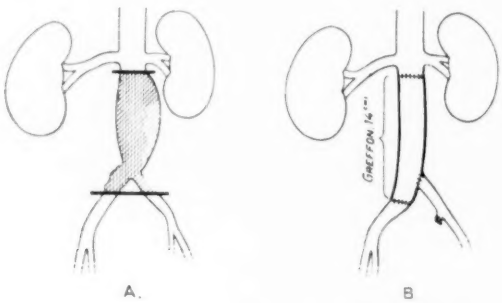


Fig. 2.—Diagram of operation. The 14-cm. graft was anastomosed end-to-end with the aorta above and the right common iliac below. After removal of its obstruction, the left common iliac artery was anastomosed by its end to the side of the graft.

Fig. 3.—Postoperative aortograph. The graft has kept a normal caliber; the two iliac arteries are perfectly delineated.

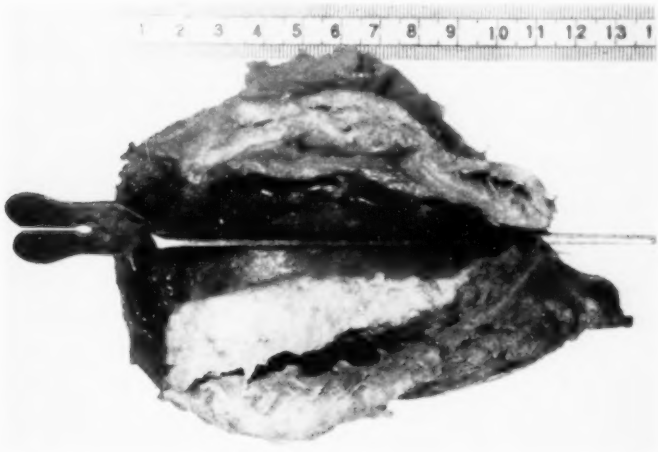


Fig. 4.—Operative specimen. The specimen is cut to demonstrate the importance of the peripheral clot, which allows the persistence through its center of a canal which was shown on the aortograph.

immediately above the other anastomosis. After removal of the clamps, the three anastomoses were widely patent, and the femoral pulses were felt to be equal on the two sides.

A check aortograph was carried out two months later and showed perfect function of the graft, which was not at all dilated but was widely patent, as were also the iliac and femoral arteries (Fig. 3).

Three months after the operation the patient was in perfect health. The femoral pulses were strong and equal and also the posterior tibial and dorsalis pedis arteries.

The specimen, 15 cm. long, was made up of a large sac with a very thin wall which was calcified in many places and was completely filled by a large clot which had a canal through its center about 3 cm. in diameter (Fig. 4).

Histological Examination.—The aortic wall, extremely altered, shows the following changes from the cavity of the aneurysm outward: There is a much thickened intima, transformed into an amorphous mass not taking up the stain, studded with fatty acid crystals, and showing calcareous degeneration in the deepest part. Immediately under the calcified areas is the beginning of the media, still recognizable in this region from several areas of elastic fibers which are fragmented. The outer four-fifths of the media are totally lacking in elastic tissue. In contrast, the muscle fibers are almost normal in appearance but fibrous tissue is more prominent. The main feature, together with the destruction of elastic tissue, is the presence throughout the outer half of the aorta of masses of lymphocytic cells accompanying the vasa vasorum; these cells form concentric sheets but also are seen sometimes to follow the vessels at right angles to the layers of the wall. This periarteritis is accompanied in places with endoarteritis obliterans, several vasa vasorum being completely obstructed.

The narrow adventitious layer contains the same perivascular lymphocytic infiltration, the same obliteration of a number of vasa vasorum, and, moreover, a definite lymphocytic hyperplasia in lymph nodules.

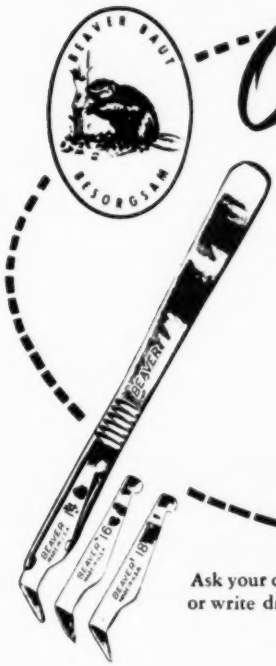
No inflammatory sclerosis was seen.

In summary, the lesion is an aneurysm with marked changes in the walls and calcium deposition. The endarteritis and periarteritis of the vasa vasorum would suggest an inflammatory process without any specific indication as to its nature.

CONCLUSIONS

A case of aneurysm of the abdominal aorta extending from the renal to the iliac arteries is reported. The method chosen for its excision was a combined abdominothoracic approach on the left; this gave the necessary exposure of the aortic bifurcation and the origin of the renal arteries.

The reestablishment of continuity of the aorta was assured by a graft of human aorta which had been preserved for three weeks. An aortograph carried out two months after the operation showed perfect permeability of the graft as well as of the iliac arteries, of which the left one had been obstructed. Five months after surgical intervention the pulse and oscillations in both legs were normal and equal.



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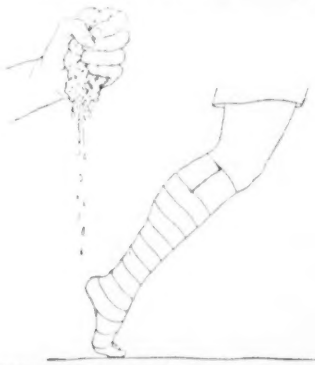

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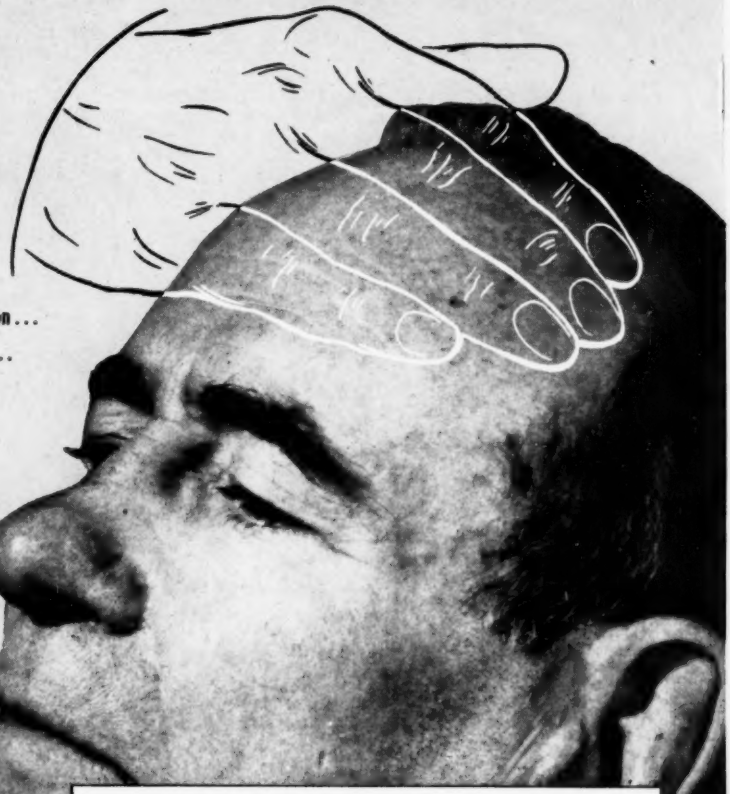

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